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Department of Science and Art
of the Committee of Council on Education.

CATALOGUE

OF

SHIP MODELS AND MARINE ENGINEERING

IN THE

SOUTH KENSINGTON MUSEUM.

WITH

CLASSIFIED TABLE OF CONTENTS, AND AN ALPHABETICAL INDEX OF EXHIBITORS AND SUBJECTS.

LONDON:
PRINTED BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
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1889.

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1889

CATALOGUE OF THE COLLECTION

OF

Ship Models and Marine Engineering in the South Kensington Museum.

PREFACE.

THE present collection of Models of ships of the Mercantile Marine, and Ships of War, has been acquired by loans and gifts from private sources to the South Kensington Museum, since the formation in 1864 of a collection of Ship Models illustrating naval architecture and marine engineering.

On the removal to Greenwich in 1873 of the collection of naval models belonging to the Admiralty it was determined to continue, as part of the collections of the South Kensington Museum, an exhibition of the Models of Ships and tackle in connexion with them, acquired from time to time by the Science and Art Department of the Committee of Council on Education; these now form a tolerably complete series.

To the Models of ships are added Models and Drawings of steam-engines applied to the propulsion of ships by screw propellers or paddle wheels, also of marine steam boilers, engine and boiler accessories, as well as various other illustrations of steamship machinery in general.

A valuable nucleus for the study of the science of marine architecture and engineering thus exists, and is a permanent and extensive portion of the National Collections of the Museum.

Great assistance has been received from many private ship-building and engineering firms in forming the collection of Marine Models for public instruction in London.

I 55109. 500.—6/89. Wt. 7606. A 2

As the collection is necessarily in an ever varying and fluctuating state, throughout the catalogue the date is given at which models and objects have been contributed, are lent, or otherwise procured.

The annexed account of the history of the "Navy Office" or present Admiralty, taken from the preface to the catalogue of the models formerly exhibited by the Admiralty in the South Kensington Museum, may be found interesting.

H. S.

December, 1888.

The following short historical sketch of the Navy Office, extracted chiefly from the 5th Report of the Commissioners of Inquiry, dated 14th February 1788, (page 25) contains some very interesting information:—

"The records of the office do not furnish us with any information further back than July 1660, but we understand that the first establishment of Royal Navy office was in the reign of King Henry VIII., who appointed certain officers, under the title of principal officers of his navy, to manage the civil branches thereof, under the Lord High Admiral; but these officers had no positive instructions for their guidance in the execution of their duty until the reign of Edward VI., when certain ordinances were issued for the conduct of the officers entrusted with the management of the marine affairs, which ordinances form the basis of all later instructions given for the conduct of the officers to whom the management of the civil branches of the Navy was committed. The officers at that time appointed to this duty were the Vice-Admiral of the Fleet, the Master of the Ordnance, the Surveyor of Marine Causes, the Treasurer, the Controller, the General Surveyor of the Victualling, the Clerk of the Ships, and the Clerk of the Stores, who were directed to meet once a week at the office on Tower Hill, to consult together for the good order of the Navy, and to report their proceedings once a month to the High Admiral; particular duties were also assigned to each member.

"The affairs of the Navy appear to have continued under the management of such officers until the time of King James I., who, in the sixteenth year of his reign, issued a commission under the great seal to Sir Thomas Smith and others, to inquire into the frauds and abuses which had been committed in the Navy, with power to remedy the same, and to manage, settle, and put the officers of the Navy into a right course. This commission was determined upon the demise of King James I. in 1625, when his successor, King Charles I., issued a new commission to the same persons. By this commission the offices of the controller and surveyor were suspended during its continuance, and the same

continued in force until the year 1628, when t was made void by a new commission, restoring the management of the affairs of the Navy to the ancient principal officers established in the reign of King Edward VI.; but between this time and breaking out of the Civil War several commissions appear to have been issued for regulating and settling the affairs of the Navy, during the continuance of which the functions of the original principal officers were always suspended.

"Upon the restoration of King Charles II. his Majesty constituted a Navy Board, by commission under the great seal, consisting of the Treasurer, Controller, Surveyor, and Clerk of the Navy, who were styled principal officers, to whom, on the 4th July 1660, three commissioners were added, to assist the said principal officers in the management of the affairs of the Navy.

"In January 1661 the Duke of York (then Lord High Admiral) established certain instructions now in use (1778) for the conduct of the four principal officers; the other three being commissioners at large, had no particular line of duty allotted to them until the year 1666, when one of them was directed to take upon him so much of the controller's duty as related to the examination and control of the treasurer's accounts; another that part relating to victualling accounts; and in the year 1671, the third commissioner had that part of the controller's duty which related to the examination and control of the storekeeper's accounts, assigned to him, which, with the addition of one commissioner at large, is the present (1778) arrangement of the Navy Board."

In consequence of the great increase of the Navy, these arrangements were found incomplete and insufficient to insure the strict investigation and examination of accounts, the direction and proper conduct of correspondence and supervision of stores; instead of the commissioners presiding over separate departments, committees were formed, and the business divided so as to admit of competent officers in each branch, possessing time and opportunity, to examine, digest, and conduct the parts allotted to them. Under this idea, by Order in Council of 8th June 1796, the Navy Board was divided into the three following committees:—

A Committee of Correspondence.
A Committee of Accounts.
A Committee of Stores.

The controller to belong to and preside at every committee.

The designing, building, and repair of ships was in the hands of the surveyors, of whom at one time there were three, and generally two, under the presidency of the controller.

In the year 1796 the Board consisted of the following members, viz.:—Sir Andrew Snape Hammond, Bart., Controller; Charles Hope, Esq., Deputy Controller; Sir John Henslow and Sir W. Rule, Surveyors; George Marsh, Esq., George Rogers, Esq., William Palmer, Esq., Sir William Bellingham, Bart., Harry Harwood, Esq., and Samuel Gambier, Esq.

The office of Deputy Controller was abolished in the year 1816. In the following year the Transport Board, created in 1793, was

broken up, and a Transport Committee was formed at the Navy Board.

A surveyor was reduced in 1822, and a civil commissioner in the same year, leaving at the Board the following persons, viz.:— one Controller, two Surveyors, three Naval Officers, and three Civil Commissioners, in the whole nine, and thus employed :— Two at the Committee of Correspondence, two at the Committee of Accounts, two at the Committee of Stores, two at the Committee of Transport, with the controller at the head of each.

In 1832, during the presidence of Sir James Graham at the Board of Admiralty, the Navy Board was abolished, the civil affairs of the Navy being for the future conducted by the principal officers, under the direct control of the Board of Admiralty. At that time the department charged with the design and construction of ships consisted of a Surveyor (a naval officer) and two Assistant Surveyors. In 1857 this department was placed under a Controller (a naval officer), one Chief Constructor, and one Constructor, to which staff an Assistant Constructor was added in 1861. In 1864, by Order in Council, the constitution of the office was altered to a Controller, a Chief Constructor, and three Assistant Constructors.

The several Royal Dockyards were established as under :—

Deptford - Early in the reign of Henry VIII. Closed April 1869.

Woolwich - Called by Camden the Mother Dockyard, in the reign of Henry VIII., about 1509. Closed October 1st, 1869.

Chatham - In the reign of Queen Elizabeth, on the site of the present gun wharf; removed to the present site about the year 1622.

Sheerness - Established in the reign of Charles II., about 1661. The present dockyard and basins were completed about the year 1823.

Portsmouth - In the reign of Henry VIII. In 1666 a dry dock and the Commissioner's house were built; and in 1848 the steam factory and steam basin were formed.

Plymouth - Prior to 1691, the Master Shipwright and workmen were borne on board of a ship fitted for their reception; and in 1693, in the reign of William and Mary, the dockyard was completed. In the year 1824, the name was changed from Plymouth Dock to Devonport.

Milford - - A temporary yard, prior to 1815, at which time it was removed to Pater Hobb's Point, and is now known as Pembroke Dockyard.

CLASSIFICATION

Of the Collection of SHIP MODELS and MARINE ENGINEERING in the SOUTH KENSINGTON MUSEUM.

Class I. MODELS of ships and boats. Sea-going ships. Coasting vessels, fishing and pilot boats, sailing barges. Yachts. River steamboats and canal boats. Ship's boats, life-boats and life-rafts, pleasure boats. Ships and boats not of modern European form. Page 8–124.

Class II. MODELS illustrating modes and details of construction. Wooden ships. Composite ships. Iron ships. Steel ships. Page 125–160.

Class III. MARINE STEAM ENGINES AND BOILERS. Boilers. Main engines for ships. Engines for launches. Donkey engines. Fittings and accessories peculiar to marine engines and boilers. Page 161–215.

Class IV. MODES OF PROPULSION. Masts and yards, rigging, sails. Oars. Paddle-wheels, screw and other propellers. Page 216–247.

Class V. APPLIANCES used in ships. Steering apparatus. Capstans and windlasses. Anchors and cables. Pumps, tanks, &c. Ventilation, Fittings. Page 248–261.

Class VI. APPLIANCES used in building and repairing ships. Floating docks. Slipways. Masting shears. Page 262–269.

Class VII. DRAWINGS and photographs. Working drawings of ships. Working drawings of engines and boilers. Miscellaneous subjects. Page 270–287.

APPENDIX. Miscellaneous objects relating to ships and appliances. Page 288–310. 313–320.

ALPHABETICAL INDEX. Page 323.

CATALOGUE.

CLASS I.

Models of Ships and Boats.

IMPERIAL MARINE.

1. WHOLE MODEL. Rigged. Scale $\frac{3}{16}$-in. to 1 ft. H.M.S. "RACOON," 22 guns, 400 horse-power, nominal.

Lent by H.R.H. the Duke of Edinburgh, K.G. 1865.

Note.—The "RACOON," 22 guns, 400 horse-power, length 200 ft. 1 in., breadth 40 ft. 4 in., depth 22 ft. 8 in., tonnage 1,467, was laid down at Chatham Yard in April 1856. Launched in April 1857. Designed by Surveyor's Department, Admiralty.

Note.—There were also built on the same lines the "CHALLENGER," at Woolwich in 1858, and the "CLIO," at Sheerness in 1858.

The armament was as follows :

No.	Prs.	Weight.	Length.
		cwt.	ft. in.
20	8-in.	60	8 10
2	68-pr. pivot	95	10 0
Total 22			

The complement of men was 280.

2. WHOLE MODEL, rigged; on a scale of $\frac{1}{2}$-in. to 1 ft. H.M.S. "NORTHUMBERLAND," 26 guns, 1,350 horse-power, nominal. Length 400 ft., breadth 59 ft. 3½ ins., depth 21 ft. 1 in., tonnage 6,621. Designed by the Controller's Department, Admiralty.

Lent by the Millwall Iron Works Company. 1865.

Note.—The "NORTHUMBERLAND" was laid down in 1861 by Messrs. C. J. Mare & Co., at their yard at Millwall, and was completed in 1865 by the Millwall Iron Works and Shipbuilding Co.

The model showing three masts and 50 guns was made before the masting and armament of the ship had been determined.

There were also built on the same lines the "MINOTAUR" and "AGINCOURT."

The armament of the "NORTHUMBERLAND" was eventually:

	No.	Prs.	
Main deck	4	300	12-ton guns.
"	18	100	6½ "
Upper "	4	100	6½ "
	Total 26		

3. HALF BLOCK MODEL. Scale ¼-in. to 1 ft. H.M.'s ship "WATERWITCH," built of iron, 2 guns, 160 horse-power. Length 162 ft., breadth 32 ft., draught of water 10 ft. 10 in. forward, 11 ft. 4 in. aft. Tonnage 778. Displacement 1,190 tons. Speed 9·255 knots. Area of midship section immersed, 344 square ft. Built by contract by the Thames Iron Shipbuilding Company, Millwall. Laid down in November 1864; launched in June 1866.

Designed by Rear-Admiral Geo. Elliot and the Controller's Department, Admiralty. Propelled on the hydraulic or turbine principle, invented and patented by Mr. D. Ruthven.

The armament was two 6-ton rifled guns.

The complement of men was 80. 1869.

4. WHOLE MODEL, H.M.S. Indian relief steam troopship "JUMNA." Built 1866, by Palmer's Shipbuilding Company, Jarrow-on-Tyne. Length 365 ft., breadth 48 ft. 9 in., depth 42 ft., tonnage gross 4,174, horse-power 700 nominal, speed 14½ knots per hour. Scale 1-48th full size.

Palmer's Shipbuilding Company, Limited, Jarrow-on-Tyne. 1874.

Note.—There were also built on the same lines, about the same time, the "MALABAR," by Messrs. Napier & Sons; the "CROCODILE," by Messrs. Wigram; the "SERAPIS," by the Thames Iron Shipbuilding Company; and the "EUPHRATES," built of iron, 700 horse-power. A class of five to form a direct service for the transport of troops to and fro between England and India. Length of the "EUPHRATES" 360 ft., breadth 49 ft., draught 19 ft. forward, 21 ft. aft, tonnage 4,206, speed 14·718 knots. Built by contract by Messrs. Laird, Brothers. Laid down in May 1865, launched November 1866. Designed by the Controller's Department, Admiralty.

In 1882 there was added to these troopships the "CLIVE," built partly of steel and partly of iron, by Messrs. Laird Brothers, and engined by them. Dimensions 300 ft. × 45 ft. 8 in. × 25 ft. 6 in. Tons, B.M. 3,003. Indicated horse-power 2,000. The S.S. "HIMALAYA," built 1853; the "TYNE," built 1878; the "ORONTES," built 1862; the "TAMAR," built 1862; the "ASSISTANCE," built 1875, are also special troopships in the Imperial marine service.

For a model of H.M.S. "Himalaya" see page 13.

5. WHOLE MODEL, H.M.S. armour-plated turret ship "CAPTAIN." Tons 4,472. Horse-power nominal 900. Built 1869 by Laird Bros., Birkenhead. Laid down 1867.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—H.M.S. "CAPTAIN," built of iron, on the designs of the late Captain Cowper Coles, R.N. (1866), was lost off the coast of Spain on the night of the 6th September 1870, while keeping station with the Channel Squadron.

The length of the ship was 335 ft., beam 53 ft. 3 ins.; draught of water, 23 ft. 6 ins.; displacement, 7,650 tons.

The vessel was full ship-rigged and carried tripod masts and yards of iron. She had a poop and forecastle, and a spar deck 26 ft. wide running her entire length. She was driven by two pair of double engines and twin screws. Engine cylinders 80 ins. diameter, with 3 ft. 3 ins. stroke. The effective power of these engines was 5,400 horse-power. Steam was supplied to them by 8 boilers with 28 furnaces.

H.M.S. "CAPTAIN" carried 6 rifled guns. In each of her turrets (2) were two 25-ton guns, 600-prs.; one 6½-ton 100-pr. gun in her bow; and one 6½-ton 100-pr. gun in her stern, for chasing. Her hull armour plates were 7 and 8 ins. thick, backed with teak 12 ins. thick, fastened to ship's skin 1½ ins. thick. The turret plates were 9 and 10 ins. thick. The upper deck was carried on iron beams 14 ins. deep, covered with iron plating 1½ and 1 in. thick and teak planking 6 ins. thick.

The "CAPTAIN" was entirely built, engined, and fitted by Messrs. Laird Brothers, at Birkenhead.

6. WHOLE MODEL of the first screw-steamer in the British Navy, "MERMAID" afterwards named the "DWARF." Built in 1840 by Ditchburn and Mare; engined by Rennie. Purchased from J. and G. Rennie by the British Admiralty, according to Sir George Cockburn's advice, and on the condition that she should steam 12 miles per hour (7th March 1842). Tried 15th May 1843. Mean speed of 6 runs, 12·142 miles.

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

7. HALF BLOCK MODEL of H.E.I.C. paddle steamer "NEMESIS," 1839. Length 169 ft., breadth 29 ft., depth 10 ft. 3 ins. 660 tons. 120 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—The paddle steamer "NEMESIS" was built of iron for the Hon. East India Company for service on the coast of India, and armed with two 32-pr. pivot guns.

This vessel, as well as the "PHLEGETHON," a similar but rather smaller vessel, though only drawing 5 feet of water, made the passage out to India round the Cape, a drop rudder and sliding keel, as shown on model, being fitted for that purpose.

Under the command of Captain William Hall, R.N., the "NEMESIS" did distinguished service in the China wars, 1842, 1856. Her light draught enabled her to perform service which no wooden vessel in the fleet was able to accomplish.

At the same time the "MEDUSA" and "ARIADNE," of 432 tons, and each carrying two 24-pr. pivot guns, were built for the same service.

8. HALF BLOCK MODEL of the paddle steamer "GUADALOUPE," 1842. Length 187 ft., breadth 30 ft., depth 16 ft. 788 tons. 180 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—The success of the above steamers "NEMESIS," "MEDUSA," and "ARIADNE" (the first iron vessels armed with heavy guns) induced the agents of the Mexican Government to order the steam frigate "GUADALOUPE," of 800 tons and 180 horse-power, armed with two 68-pr. pivot guns, one at each end, and four 24-pr. broadside guns. The satisfactory reports made upon the construction and trials of this vessel by the late Mr. Large and other officers, induced the English Government to entrust Mr. Laird with the designing and building of the iron paddle-wheel frigate "BIRKENHEAD," 1,400 tons, one of the first iron war ships in the English navy; this ship was launched in 1845.

9. WHOLE MODEL, rigged. H.M.'s double-turret, armour plated, screw ship "NEPTUNE." Iron. Built 1876. Displacement 9,000 tons. Horse-power 8,500 indicated. Engines and machinery, by John Penn & Sons, Greenwich. Length 300 ft., breadth 63 ft., depth 25 ft., draught 16 ft. 6 ins. Speed 14½ knots. Armament, four 38-ton Armstrong guns.

Lent by Messrs. Samuda Brothers, Poplar, E. 1882.

Note.—The "NEPTUNE" was originally built for the Brazilian Government, and called the "INDEPENDENCIA." She was afterwards purchased by the British Government in 1878 for the Royal Navy. Her armour is 12 and 10 inches thick on hull, and 13 inches on the turrets.

10. WHOLE MODEL. H.M.S. "BELLEISLE" and "ORION." Twin-screw armour-clad corvettes. Iron. Built 1876-79. Central battery ships. Four 25-ton Armstrong guns. Displacement 4,700 tons. Horse-power 3,900 indicated. Engines and machinery by Maudslay, Sons, and Field, London.

Lent by Messrs. Samuda Brothers, Poplar, E. 1882.

Note.—The dimensions of H.M.S. "BELLEISLE" and "ORION" are about the following:—

Length 245 ft.; depth 22 ft. The armour-plating is 12 ins. thick on broadsides, diminishing to 5 ins. at ships' ends, and extending to 5 ft. below water line. The ships are provided with short rams. The speed 13 knots. They were originally built for the Ottoman Government, and were afterwards purchased by the British Government in 1878 for the Royal Navy.

10A. WHOLE MODEL. H.M.'s single-turreted armour-clad ship of war "VICTORIA." Built 1887.

Lent by Sir W. Armstrong, Mitchell, & Co., Newcastle-on-Tyne. 1887.

Note.—H.M.S. "VICTORIA," built of steel, was launched at Elswick Yard, 1887. Her length is 340 ft.; breadth 70 ft. Displacement 10,500 tons. Indicated horse-power 12,000. She is driven by twin-screws; and will be armed with two 110½-ton breech-loading guns; one 10-in. breech-loading gun; 12 6-in. breech-loading guns; rapid-fire guns; and torpedo firing tubes. She is also provided with a powerful ramming bow. Estimated speed 17 knots per hour. The armour plates of steel are 18 inches thick. The backing is 6 inches thick.

The engines of H.M.S. "VICTORIA" constructed by Messrs. Humphrys and Tennant, Deptford. They are on the most recent form of upright compound engines with inverted cylinders.

The boilers of steel, working at a steam pressure of about 150 lbs. per square inch, are of the newest pattern.

Ship's crew numbers 550 men and officers, of which 110 are employed in attending to the machinery department.

H.M.S. "SANSPAREIL," built 1887, by the Thames Iron-works Co., Millwall, is a sister ship to H.M.S. "VICTORIA."

For other models lent by Sir Wm. Armstrong, Mitchell, & Co., see pages 14, 90, 267.

11. WHOLE MODEL, rigged. H.M.'s twin-screw despatch vessels "SURPRISE" and "ALACRITY." Built and engined 1885, at Jarrow.

Lent by Palmer's Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne. 1887.

Note.—These sister despatch vessels, built of steel, are 250 ft. long, 32 ft. wide, and 20 ft. deep.

Displacement 1,400 tons. Average speed at sea 18½ knots.

The engines are two-cylinder compound inverted. The cylinders are 26 and 50 inches diameter, with a stroke of 34 inches. Indicated horse-power 3,017.

For other models lent by Palmer's Shipbuilding Co., see pages 59, 198.

12. WHOLE BLOCK MODEL. Paddle-wheel gunboats "BANN" and "BRUNE." Tons 287, horse-power 80. Built of iron, 1856, for the Admiralty, by John Scott Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

12A. WHOLE MODEL, rigged. On a scale of ¼-inch to 1 foot. H.M.'s troopship "HIMALAYA," 1853.

Lent by Mr. John Hughes, per Mr. C. F. Henwood, Great St. Helens, E.C. 1888.

Note.—The "HIMALAYA" was built of iron by Messrs. C. J. Mare & Co., Blackwall, for the Peninsular and Oriental Steam Navigation Company, from whom she was purchased by the Government in 1854, and fitted as a troopship for H.M.'s service.

The dimensions of the "HIMALAYA" are as follows:—Length 339 ft.; breadth 46 ft.; depth 34 ft. 4 ins.; draught of water 19 ft. Tons 3,504. Speed 12 knots per hour. Her screw propeller was driven by engines of 700 horse-power. Constructed by John Penn and Sons, Greenwich. The ship carried six 32-pounders, 25 cwt. guns. Her complement of men was 213.

IMPERIAL MARINE.—FOREIGN SHIPS.

13. WHOLE MODEL, rigged. The Turkish iron armour-clad screw frigates "OSMANEA," "AZIZEA," and "ORKHANEA." Length 293 ft., beam 36 ft., tonnage 4,222, builders' measurement. Guns 42. Nominal horse-power 900. Constructed for the Imperial Ottoman Government by R. Napier & Sons, 1865.

Presented by Messrs. R. Napier & Sons, Glasgow. 1867.

14. WHOLE MODEL, rigged. The Imperial German armour-plated ship of war, "KONIG WILHELM"; designed by Sir E. J. Reed. Built 1869 by the Thames Iron Works and Shipbuilding Co., Millwall.

Note.—The ship's principal dimensions are:—Length 355 ft.; breadth 60 ft.; depth 41 ft. 9 ins.; tons 6,000;

horse-power 1,150, nominal. Engines by Messrs. Maudslay, Sons, and Field.

Lent by Sir E. J. Reed, K.C.B., M.P. 1876.

15. WHOLE MODEL. Armour-clad turret ships "EL PLATA" and "LOS ANDES." Argentine Republic. Built by Laird Brothers, 1875. Length 180 ft. 8 ins., breadth 44 ft., depth 12 ft. 5 ins. Tons 1,588. Load draught 9 ft. 6 ins. Horse-power 750 indicated. Ships carry two 300-pr. Armstrong rifled guns.

Messrs. Laird Brothers, Birkenhead. 1879.

16. WHOLE MODEL. Iron twin-screw gunboats "CONSTITUCION" and "REPUBLICA." Built by Laird Brothers, 1875. Length 106 ft., breadth 30 ft., depth 10 ft. 6 ins. Tons 421. Load draught 7 ft. 6 ins. Horse-power 420 indicated. Armament one 600-pr. Armstrong rifled gun.

Messrs. Laird Brothers, Birkenhead. 1879.

17. WHOLE MODEL. Imperial Japanese steel-protected cruisers "NANIWA KAN" and "TAKACHIHO KAN." Built 1886, of steel.

Lent by Sir William Armstrong, Mitchell, & Co., Newcastle-on-Tyne. 1887.

Note.—The "Naniwa Kan" and "Takachiho Kan" are propelled by twin-screws. Displacement 3,700 tons. Speed 19 knots. Armament, two 10-in. R.B.L. guns; six 6-in. R.B.L. guns; two 6-pr. rapid-fire guns; 10 four-barrel 1-in. Nordenfeldt guns; two Gatling guns, and four torpedo-firing guns. Their principal dimensions are,—length 300 ft., breadth 46 ft.; draught of water 18½ ft. Indicated horse power collectively 7,500.

For other models lent by Armstrong, Mitchell, & Co., see pages 12, 90, 267.

18. PHOTOGRAPH. Protected cruiser "ESMERALDA." 3,000 tons displacement; speed 18 knots. Built of steel, and engined 1884, for the Chilian Government, by Sir W. G. Armstrong, Mitchell, & Co., Limited. Low Walker, Newcastle-on-Tyne.

Presented. 1884.

Note.—The "Esmeralda" measures 270 ft. long, 42 ft. beam, draught of water loaded 18½ ft. She is built of steel, and framed on the transverse system. She is minutely subdivided into water-tight compartments in "flats." The engines, constructed by R. and W. Hawthorn, of Newcastle, are horizontal two-cylinder compound; cylinders 41 and 82 ins. diameter. Stroke 3 ft. Total indicated horse-power 6,500. Steam is supplied by four double-ended steel boilers, 13 ft. diameter, 18½ ft. long, with six furnaces in

each. Boiler steam pressure 90 lbs. per square inch. Forced draught arrangements are fitted to each boiler room. Her armament, two 25-ton 10-in. B.L. guns, six 4-ton 6-in. B.L. guns, two rapid-fire 6-pr. guns, Elswick pattern; six machine guns; on each broadside three 6-in. 80-pr. guns.

19. COLOURED LITHOGRAPH. The United States' iron-clad ram "DICTATOR," 1863.

Transferred from the Patent Museum. 1886.

Note.—The "Dictator" was designed by J. Ericsson, and built 1863, at the Delamater Iron Works, New York. Her length was 320 ft., breadth 50 ft., depth of hold 22 ft., draught of water 20 ft. Diameter of turret, inside, 24 ft.; thickness of turret, 15 ins. At each end of the vessel was a ram, and she was armed with two 15-in. guns. Her propeller (21 ft. 6 ins. diameter and 34 ft. pitch), was driven by two Ericsson vibrating lever engines, with cylinders 100 ins. diameter; length of stroke 4 ft. Steam was supplied by six boilers, having a total heating surface of 34,000 square ft. and a boiler-grate surface of 1,120 square ft.

IMPERIAL MARINE.—SAILING SHIPS.

20. WHOLE MODEL, rigged. Scale ½-inch to 1 foot. H.M.S. "AJAX," 64 guns. Tonnage 1,953. Laid down at Messrs. Randall's yard, on the Thames, in 1795, launched in 1798, burnt in 1807.

This model was constructed by the late Sir Joseph Sydney Yorke, Bart., between the years 1797 and 1808.

Presented by the Earl of Hardwick. 1865.

21. WHOLE MODEL. H.M.S. "CHESTER," 50 guns. Built at Chatham or Woolwich, about 1670.

Lent by Mr. J. Dafforne. 1869.

Note.—With this model are also exhibited the lower masts, yards and spars, bowsprit, and other rigging gear of the ship.

22. WHOLE MODEL, rigged. The 74-gun French ship-of-war "LE SCEPTRE." Date about 1700–1750. Full-rigged. No sails.

Purchased. 1871.

23. WHOLE MODEL, in bone, of a three-decker line-of-battle-ship, made by French prisoners in England during the Peninsular War, 1812.

Lent by Mr. Vaughan Pendred, C.E. 1876.

24. WHOLE MODEL. A wooden 36-gun frigate. About 1780. Scale ¼ in. to 1 ft.

Purchased. 1886.

Note.—The model has poop and topgallant forecastle, and exhibits the whole of the ship's upper deck fittings and guns. Three models of ship's boats are also exhibited.

25. WHOLE MODEL, rigged. A Revenue cutter. About 1810–30. Scale ¼ in. to 1 ft.

Purchased. 1886.

Note.—This model is built and represents an old Revenue cutter of 14 guns. The detail of the upper deck fittings is complete. The rigging and gear of the cutter are carried out with extreme exactitude, and the little figures in the shrouds represent part of the vessel's crew.

26. WHOLE MODEL, rigged. An English frigate of 32 guns. 1750.

Presented by the late Mr. T. S. Robins. 1881.

Note.—The model represents a wooden ship, and shows timbers, upper-deck beams, and fittings, poop, and forecastle.

27. WHOLE MODEL. H.M.S. "QUEEN CHARLOTTE," 1790. Wooden ship; 100 guns. Built at Chatham; burnt off Leghorn in 1800.

Lent by Mr. Hyde Clarke, St. George's Square, S.W. 1881.

28. WHOLE MODELS. Four models representing old English wooden ships of war. 1790–1820. Two ships of the line; a sloop; and a corvette.

Purchased. 1885.

29. WHOLE MODEL, rigged. French line-of-battle wooden ship, "LE VENGEUR," 74 guns. 1790.

Lent by Mr. Sidney W. Woodgate, Kensington Park Road, W. 1881.

Note.—The model is said to be on a scale of $\frac{2}{10}$ in. to 1 ft., and constructed in 1798 by French prisoners at Porchester Castle. It is of bone, and richly carved. "Le Vengeur" was sunk in action off Brest with the British fleet under Lord Howe, 1794.

30. WHOLE MODEL, rigged. H.M.S. "TRYALL," 18-gun sloop of war; early XVIII. century. The "Tryall" was one of Admiral Anson's squadron to the Pacific in 1740, and was sunk there during the cruise.

Purchased. 1886.

Note.—The Admiralty possess, it is believed, drawings of H.M.S. "Tryall." The model of her is interesting from the

historical view of the ship as well as from her form and rig, both of which the model represents fully.

31. WHOLE MODEL, rigged. H.M.'s Line-of-battle ship "CALEDONIA." 120 guns. Designed by Sir William Rule, and built 1808.

Lent by Mr. R. F. Harvey, Fairfield, Liverpool. 1888.

Note.—H.M.S. "CALEDONIA," a line-of-battle ship of three decks, was laid down at Devonport Yard in 1805 and launched 1808. Her dimensions were,—length 205 ft.; breadth 54 ft. 6 ins.; depth 23 ft. 2 ins. Tonnage 2,616. When launched the vessel had a square stern, which was afterwards made circular. The armament was as follows:—

	No.	*Prs.*
Lower deck - - -	32	32
Middle „ - -	34	24
Main „ - - -	34	18
Quarter „ - -	16	12
Forecastle - - -	4	12
	120	

The complement of men was 875.

In 1856 the "CALEDONIA" was appropriated as the Hospital Ship at Greenwich and her name changed to "DREADNOUGHT."

There were also built on the same lines the "BRITANNIA," launched at Plymouth, 1820; "PRINCE REGENT," at Chatham in 1823; and the "ROYAL GEORGE," at Chatham in 1827.

31*a*. WHOLE MODEL. H.M. 18-gun brig "FANTOME.' Built from designs by Sir William Symonds about 1838. The following are about the dimensions of the vessel, length 120 ft., beam 33 ft., depth 14 ft. Tonnage 500.

Purchased. 1888.

Note.—The model is built, planked, and decked properly. The lower masts and the topmasts are represented. On the same lines about the same time were built H.M.S. "PILOT," "ACORN," "BITTERN," "DESPATCH," "ELK," "GRECIAN," "HERON," and others.

IMPERIAL MARINE.—DESIGNS.

32. SERIES OF MODELS, presented in 1867, by Messrs. R. Napier & Sons, Glasgow, illustrating a system of proposals and plans for combined turret and broadside navies, by the late Vice-Admiral Edward Pellew Halsted, R.N.

The ships, designed by C. F. Henwood, Esq., Naval Architect, are fitted on the turret and iron tripod mast system of the late Captain Cowper P. Coles, R.N., C.B.

The guns proposed for the armament of these ships were to be constructed and rifled on the principle for heavy ordnance of Sir Joseph Whitworth, Bart.; and mounted upon the muzzle-pivoting gun carriages designed by Captain T. B. Heathorn, R.A.

a. WHOLE MODEL, full-rigged, of the proposed ship-of-war "DREADNOUGHT," classed as a first-rate; 7 turrets.

Turrets - - - - 7
Number of guns in turrets - 14 of 9-in. calibre.
Number of broadside guns - 4 of 7-in. calibre.
and - - - 10 of 4-in. „
Tonnage, 10,764, builder's old measurement.
Nominal horse-power, 1,300.
Length of ship, 455 ft. Breadth, 70 ft.
Depth, 28 ft. Load draught, 26 ft. 6 in.
Designed May 1886. Scale ¼ in. to 1 ft.

Note.—The masts and rigging of this model illustrates the following conditions:—

Foremast: shows the masts as it would appear when "prepared for action," and ship steaming head to wind.

Mainmast: represents the position of the yards and sails when "sailing close-hauled."

Mizen-mast: represents the yards squared and dressed, ship lying in harbour.

b. WHOLE MODEL, full-rigged, of the proposed ship-of-war "ACTIVE," classed as a corvette or sixth-rate. 2 turrets.

Turrets - - - 2
Number of guns in turrets - 4 of 9-in. calibre.
Number of broadside guns - 10 of 7-in. „
Tonnage, 4,926, builder's old measurement.
Nominal horse-power, 1,000.
Length of ship, 367 ft. 6 in. Breadth, 52 ft. 6 in.
Depth, 25 ft.
Load draught, 24 ft. 6 in.
Designed May 1866. Scale ¼ in. to 1 ft.

Note.—The yards on the masts of this model show the ship as "running before the wind."

c. WHOLE MODEL, unrigged, of the proposed ship-of-war or ocean despatch vessel "VEDETTE," classed as an eighth-rate ship. 1 turret.

Turret - - - 1
Number of guns in turret 2 of 9-in. calibre.
Number of broadside guns 10 to 5½ in. „
Tonnage, 3,648, builder's old measurement.
Displacement, 5,700 tons.
Nominal horse-power, 800.
Length of ship, 332 ft. 6 ins. Breadth, 47 ft. 6 ins. Depth, 23 ft.
Load draught, 22 ft. 6 ins.
Designed May 1866. Scale, ¼ in. to 1 ft.

d. HALF BLOCK MODEL of proposed ship of war "POWERFUL," classed as a second rate. 6 turrets.
Turrets - - - - 6
Number of guns in turrets - 12
Length of ship 438 ft. 9 in. Breadth 67 ft. 6 in. Depth, 28 ft.
Load draught, 26 ft. 6 in.
Tonnage, 9,652, builders' old measurement.
Displacement, 13,200 tons.

Note.—This model is on a mahogany stand, and fitted to blocks. The starboard side shows the ship as completely constructed. The port side gives a longitudinal through section of the ship's internal arrangement.

Designed May 1866. Scale ¼ in. to 1 ft.

e. HALF BLOCK MODEL of proposed ship of war "DAUNTLESS," classed as a third rate. 5 turrets.
Turrets - - - - 5
Number of guns in turrets - 10
Length of ship, 422 ft. 6 in. Breadth, 65 ft. Depth, 28 ft.
Load draught, 26 ft. 6 in.
Tonnage, 8,618, builders' old measurement.
Displacement, 12,100 tons.
Designed May 1866. Scale ¼ in. to 1 ft.

Note.—This model hangs at back of case. The starboard side shows the ship completely constructed. The port side gives a longitudinal through section of the ship's internal arrangement.

f. HALF BLOCK MODEL of the proposed ship of war "FORMIDABLE," classed as a fourth rate. 4 turrets.
Turrets - - - - 4
Number of guns in turrets - 8
Length of ship 390 ft. Breadth 60 ft. Depth 26 ft. 6 in.
Load draught 25 ft. 6 in.

Tonnage 6,778, builders' old measurement.
Displacement, 10,000 tons.
Designed May 1866. Scale ½ in. to 1 ft.

Note.—This model hangs at back of case. The starboard side shows the ship completely constructed. The port side gives a longitudinal through section, showing the ship's internal arrangement.

g. HALF BLOCK MODEL of the proposed ship of war "DEFENCE," classed as a fifth rate. 3 turrets.
Turrets - - - - 3
Number of guns in turrets - - 6
Length of ship 373 ft. 9 in. Breadth 57 ft. 6 in. Depth 26 ft. 6 in.
Load draught 25 ft. 6 in.
Tonnage 5,906 builders' old measurement.
Displacement, 9,100 tons.
Designed May 1866. Scale ½ in. to 1 ft.

Note.—The model shows starboard side, ship as completely constructed. The port side gives a longitudinal through section, showing the ship's internal arrangement. This model hangs at back of case.

h. HALF BLOCK MODEL of the proposed ship of war "VIGILANT," classed as a seventh rate. 2 turrets.
Turrets - - - - 2
Number of guns in turrets - - 4
Length of ship 346 ft. 3 in. Breadth 52 ft. 6 in. Depth 25 ft.
Load draught 24 ft. 6 in.
Tonnage 4,615, builders' old measurement.
Displacement, 7,400 tons.
Designed May 1866. Scale ½ in. to 1 ft.

Note.—This model hangs at back of case. The starboard side shows ship completely constructed. The port side gives a longitudinal through section, showing the ship's internal arrangement.

Note.—The preceding models of turret and broadside ships, designed by the late Admiral E. P. Halstead, were presented to the collection with other models of detail. 1867.

33. MODEL, midship section, showing the construction of the combined Turret and Broadside Armour-plated iron ships, proposed by the late Vice-Admiral E. P. Halstead, R.N., in 1866.
Scale ½ in. to 1 ft.
Presented by Messrs. R. Napier & Sons, Glasgow. 1867.

Note.—The system of diagonal trussing for the spar deck is a patent by R. Napier, Esq.

34. MODEL, designed to illustrate the Fore Turret and Fore Deck arrangement, in the proposed combined turret and broadside ships of war, designed by the late Vice-Admiral E. P. Halstead, R.N., in 1866.

Presented by Messrs. R. Napier & Sons, Glasgow, 1867.

Note.—This model shows proposed method for carrying spar deck, and clearing fore part of ship of hamper, so as to obtain a thorough end on line of fire.

35. MODEL, showing portion of Main Deck Battery, containing three guns, of the late Vice-Admiral E. P. Halstead's combined turret and broadside ships of war. Designed, 1866.

Presented by Messrs. R. Napier & Sons, Glasgow. 1867.

Note.—The guns are mounted upon iron carriages, designed by Captain T. B. Heathorn, R.A., on his system for muzzle pivoting.

36. MODEL, a complete working model of R. Napier's Turret designed to contain two "Whitworth" rifled 9-in. guns; and adopted for the combined turret and broadside armour-plated ships of war, proposed by the late Vice-Admiral E. P. Halstead, R.N., in 1866.

Presented by Messrs. R. Napier & Sons, Glasgow. 1867.

Note.—This model shows the steam turret revolving gear between decks, the method of supporting the turret, the upper and lower decks of ship, and internally the mounting and emplacement of the guns in the turret.

37. Hughes's Hollow Stringer, proposed for the backing of armour plates, and for strengthening ships of war. Weight per foot 71 lbs.

Presented by Messrs. R. Napier & Sons, Glasgow. 1867.

Note.—Hughes's hollow stringer was proposed by Admiral Halstead as armour plate backing for his turret and broadside ships. The cross sectional model of his ships illustrates its application.

38. Longitudinal Section of a 3-pr. Whitworth rifled gun; with elongated shell, and rifled sphere, to illustrate the rotation of projectile.

Presented by Sir Joseph Whitworth, Bart., & Co., Manchester. 1867.

Note.—The rifled naval guns of the late Sir Joseph Whitworth, Bart., were to be adopted for the armament of Admiral Halstead's proposed ships of war on the combined turret and broadside principle.

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39. HALF MODEL of a Corvette of the "ALABAMA" class. Designed from the American Confederate States Corvette "ALABAMA."

Proposed by Mr. George Turner, late Master Shipwright, Woolwich Dockyard.

Lent. 1864.

Note.—During the civil war in America, 1860–1864, the American Confederate States celebrated corvette "ALABAMA," built in England, in 1862, by Laird Brothers, of Birkenhead, was sunk in an action fought off Cherbourg on 19th June 1864, with the Federal ship-of-war "KEARSARGE." The corvette "ALABAMA" was built of wood and barque rigged. Her registered tonnage was 1,040. Length of vessel, 220 ft. Beam, 32 ft. Depth, 17 ft. She was a screw propellor vessel, and fitted with horizontal engines, of 300 nominal horse-power. She stored 350 tons of coal. Carried 8 guns. Her speed under steam 12 to 13 knots per hour, and under sail and steam combined, 15 knots per hour. The "KEARSARGE" measured over all 232 ft. Beam 33 ft. Depth, 16½ ft. Register tonnage, 1,031. She was a screw-propellor ship, fitted with engines of 400 nominal horse-power. Carried 7 guns. Her speed under steam was 13 knots per hour.

It is noteworthy that the "KEARSARGE" was protected outwardly by securely hanging all spare chain cable over her sides, amidships, covering a run of 49½ × 6 feet, and concealing the protection by inch planking. The device was the suggestion of Lt. Commander J. S. Thornton, executive officer of the "KEARSARGE."

40. WHOLE MODEL of a proposed armour-plated frigate with two batteries, carrying 6 heavy rifled guns in each, besides 28 broadside guns. Length of ship, 444 feet.

Designed by Mr. George Turner, late Master Shipwright, Woolwich Dockyard. 1864.

41. WHOLE MODEL of a proposed armour-plated frigate, carrying a battery of 8 heavy rifled guns and 14 broadside guns. Length of ship 330 feet.

Designed by Mr. George Turner, late Master Shipwright, Woolwich Dockyard. 1864

42. WHOLE MODEL of a proposed armour-plated corvette, carrying a battery of 4 heavy rifled guns and 4 broadside guns. Length of ship 210 feet.

Designed by Mr. George Turner, late Master Shipwright, Woolwich Dockyard. 1864.

43. WHOLE MODEL of a design for a four-decked ship of war, "DUKE OF KENT," to carry 170 guns.

Proposed by Mr. Joseph Tucker in 1809, when Master Shipwright of Plymouth Dockyard.

Lent by Mr. John Scott Tucker. 1865.

44. DRAWING of a proposed four decked ship, the "DUKE OF KENT," 170 guns, planned and proposed in 1809 by the late "Joseph Tucker," Esq., Surveyor of the Navy, 1813–1831.

Presented by Mr. John Scott Tucker. 1865.

The drawing shows lines, draught, profile, stern elevation, &c.

See also page 144.

45. WHOLE MODEL of a design for an armour-plated war vessel, on the turret principle. Submitted to the Admiralty in 1862.

Length 365 ft. Breadth 60 ft. Tons 6,300. Horse power 1,160. Speed 15 knots. Guns 22.

Messrs. Westwood and Baillie, Isle of Dogs, Poplar. 1865.

46. HALF MODEL of Messrs. Westwood and Baillie's design for an armour-plated turret ship, showing broadside and fore and aft angular firing.

Tons 6,300. Guns 22. Horse power 1,160 nominal.

Messrs. Westwood and Baillie. 1867.

47. WHOLE MODEL, brig-rigged, of a proposed ironclad war vessel, with turret and battery combined, on a system proposed and designed by Mr. R. Dawson.

The model represents a ship 316 ft. long, 66 ft. beam, 4,000 tons. Draught of water, 20 ft.; freeboard, 16 ft.

Presented by Mr. R. Dawson. 1870.

48. TRANSVERSE SECTIONAL MODEL in wood. Design for an armour-plated ship of war.

Contributed, 1864.

Transferred from the Patent Museum. 1886.

Note.—The designer of this ship is not known, the model is, therefore, removed from exhibition. It would appear, however, that in 1863 H. Caudwell patented a design for an armour-clad ship.

49. WHOLE MODEL. Iron-clad angulated steam ram ship. Invented by D. Dunlop.
Contributed, 1862.
Transferred from the Patent Museum. 1885.

Note.—The vessel is double ended, is propelled by a screw, at fore and after end, has four masts (of iron) made to lower down, barge mast fashion.

50. THREE WHOLE MODELS. Designs by the late Mr. Kennedy of Whitehaven, in 1862, for double ended armour clad twin screw vessels of war, driven by the "NAUTILUS" screw propellor, also proposed by Mr. Kennedy.
Presented. 1864.

FLOATING BATTERIES.

51. WHOLE MODEL of circular floating battery or turret ship, J. Elder's patent, 1867.
Transferred from the Patent Museum. 1885.

Note.—This proposal of the late Mr. John Elder, of Glasgow, is of considerable importance and interest. By the model is maintained the date of the first proposition for a floating battery ship of circular form, propelled by steam machinery and two or more screws; afterwards, 1874–1876, developed by the Russian Naval Architect, Admiral Popoff, of Nicolaieff; and known as the "POPOVKAS."

51A. HALF BLOCK MODEL of the circular armour-plated battery Russian ships of war "POPOVKA," "ADMIRAL POPOFF."
Lent by the Russian Embassy. 1876.

Note.—Two of these circular iron-clad ships of war constructed by Russia herself for the Imperial Navy, respectively, the "NOVGOROD," and "ADMIRAL POPOFF," are represented. The principal dimensions of the latter, are, extreme diameter 121 ft., mean draught of water 13 ft., height of upper deck at side from load water-line amidships 1 ft. 6 ins., height of barbette turret from load water-line 13 ft. 3 ins., displacement 3,553 tons. This vessel carries two 41-ton guns, which can be trained completely round inside the turret. The gun carriages are arranged to allow the guns to be lowered down behind the turret for loading and aiming, and to be brought up for firing. Besides the heavy guns, there are on each side of the superstructure, which contains cabins and quarters for the crew, two smaller guns of sufficient power to penetrate an unarmoured enemy. The armour plating of the vessel and turret is in two solid layers, having a total thickness of 1 ft. 6 ins. (including equivalent thickness for

the hollow iron girders behind the armour). The side armour of the vessel extends from the edge of the upper deck down to 4 ft. 6 ins. below load water-line. The upper deck is protected by deck armour 3 ins. thick, which extends from the circumference of the turret to the circumference of the vessel. The ship is propelled by eight compound vertical engines, each of 80 nominal horse-power. Four of these engines each work an independent screw of 10 ft. 6 in. diameter. The other four engines, arranged and worked in pairs, drive the middle screws of the ship, which are larger than the others, and lower down, deeper in the water. The speed of the "ADMIRAL POPOFF" is estimated at 9 to 10 knots per hour. The vessel is built of iron, with a double bottom, and is sheathed with wood and copper. The principal objects of the design of this circular ironclad are :—

1. Heavy armour and gun-carrying power, upon a limited draught of water.
2. Great steadiness of gun platform, ensuring efficient working of the guns at sea.
3. Complete protection of hull and battery by uniform thickness of armour throughout.
4. Cheapness of construction.
5. Numbers of compartments around the central vital parts of the ship which are specially effective for saving the vessel in case of torpedo attack.

IMPERIAL MARINE.—TORPEDO VESSELS.

52. PHOTOGRAPHS. Twelve photographs framed and glazed. Screw propeller Torpedo-boat launches of high speed. Constructed by donors for the British and other Governments.

Presented by Messrs. J. I. Thornycroft & Co., Church Walk, Chiswick, W. 1879.

NOTE ON TORPEDO BOATS.

The modern torpedo boat with exceptional speed is quite a recent departure in construction and design for imperial service vessels.

They may be summarised as of two classes:—Harbour and ship defence boats, and sea-going offensive torpedo vessels.

The first class appeared about 1870, and is represented by H.M's torpedo boat "LIGHTNING," built 1876 by J. I. Thornycroft & Co., Chiswick; and by the boats figured in the photographs.

Since 1880 sea-going torpedo vessels have been constructed and adopted. As types of this class the following few among the many may be mentioned: H.M.'s torpedo

sea-going vessel No. 80, built 1882–3 by Yarrow & Co., Poplar; No. 79, by Thornycroft, Chiswick; and H.M.'s torpedo vessel "RATTLESNAKE," built 1886 by Laird Brothers, Birkenhead, with a speed of 18¾ knots per hour.

Imperial Russian service torpedo vessels, built 1883 by J. I. Thornycroft, Chiswick, with a speed exceeding 20 miles per hour; and the "VYBOURG," built 1886 by J. and G. Thomson, Glasgow, with a speed of 22 miles per hour.

Royal Danish and Royal Italian service torpedo vessels, built 1881 to 1884 by Yarrow & Co., Poplar; J. I. Thornycroft & Co., Chiswick; with speeds of 20 to 24 miles per hour. The "FATUM," 1888, entirely completed in Italy at Leghorn.

Royal Spanish service torpedo vessels, "EL DESTRUCTOR," built 1886 by J. and G. Thomson, Glasgow; with a speed of about 30 miles per hour, and others by Thornycroft and Yarrow.

Imperial Austrian and German service vessels. The "FALKE," built 1885 for Austria by Yarrow & Co., Poplar, with a trial speed of 22½ knots per hour. For Germany by Thornycroft, Chiswick, in 1884; and the "BLITZ," 1884; built and completed entirely in Germany.

Amongst the most recent sea-going torpedo (twin-screw) vessels to be mentioned is the "BUONOVENTURA," built at Erith 1887–8 by the Defence Vessel Construction Company, from designs by Messrs. A. Corry and H. Tipping. Her engine-power, 2,700 indicated horse-power, is furnished by E. Scott & Co., engineers, Newcastle. Her trials, 7th March 1888, resulted in a mean speed of 17 knots or 20 miles per hour.

The highest trial speeds attained by some of these torpedo vessels of the first class has been accorded to the "ARIETE," built 1887 by Thornycroft, and to the "AZOR," built 1887 by Yarrow, each standing at the high speed record, computed as equalling 30 miles per hour.

IMPERIAL MARINE.—SUBMARINE NAVIGATION VESSELS.

53. TWO PHOTOGRAPHS. Garrett's Submarine Boat (1879), driven by compressed air. Crew, 3 men. Will run 12 miles under water.

Lent by Messrs. Cochran & Co., Birkenhead. 1882.

Note.—Submarine navigation boats are now being considered, particularly for imperial services. Since Garrett's small boat of 1879 appeared, vessels of much larger capacity, power, and submerged endurance have been constructed. J. F. Waddington, Seacombe, 1887; S. Nordenfeldt, London and Southampton, 1887; A. Campbell, E. Wolesley, C. E. Lyon,

London, 1886; Fletcher, Son, & Co., Limehouse, 1886; J. H. Tuck, New York, 1886, are some of the recent constructors and inventors of craft for submarine navigation.

CLASS I.

Mercantile Marine.—Paddle-wheel Steamships.

Note on Paddle-wheel Steamships.

Jonathan Hulls, an English mechanician, is generally credited with the first proposition in 1736 for driving a vessel by a paddle-wheel and steam-power. In 1737 Jonathan Hulls published in London a pamphlet descriptive of his invention. The Marquis de Jouffroy, at Lyons, in 1782 constructed a paddle-wheel steamer which ran on the River Soane for 15 months.

In 1786 the steamboat propelled by paddle-wheels, driven by a steam engine constructed by William Symington, was run on Dalswinton Lake, in Scotland, by Mr. Patrick Miller, who had been engaged for some time previously in experiments with paddle-wheels applied to the propulsion of vessels.

In 1801 Lord Dundas, Governor of the Forth and Clyde Canal, determined to apply steamboats upon it to haul the sloops. William Symington was the mechanician employed to achieve the scheme, and in 1802 the paddle-wheel steamer "Charlotte Dundas" came into existence.

In 1811 appeared on the Clyde the first trading steamer. She was named the "Comet," was built and engined at Glasgow, and ran regular daily journeys between Glasgow and Helensburgh. In 1813 a paddle-wheel steamboat is recorded as working on the river Yare between Yarmouth and Norwich.

In 1815 the paddle-steamer "Margery," a wooden vessel, built and engined at Glasgow, was sent thence to the Thames, and began a regular passenger and goods service between London and Gravesend. In 1818 the "Rob Roy" was built for sea-going service by David Napier of Glasgow. She plied regularly between Greenock and Belfast, and afterwards ran between Dover and Calais.

In 1825 the first paddle-wheel steamship voyage to India from England was made by the "Falcon," a sailing vessel fitted with steam-power. In 1830 paddle-wheel steamers were run regularly between Falmouth, Malta, and Corfu, with the Ionian Islands, a British Protectorate at that time. In 1857 Government contracted with the Peninsular Steam

Navigation Company for a regular service of steamers to carry mails from Falmouth weekly to Vigo, Oporto, Lisbon, Cadiz, and Gibraltar. In 1840 the Peninsular and Oriental Steam Navigation Company had completed terms with the Home and Indian authorities for the Indian Mail Service to Bombay. In 1843 the service was extended from Bombay to Calcutta, in 1845 to Ceylon and Madras, and in 1847 to China.

In 1835 Captain Claxton, R.N., promulgated the Atlantic Ocean Service. In this year was built of wood at Bristol by Patterson, and engined by Maudslay, Sons, and Field, London, the paddle-wheel steamship "GREAT WESTERN," of 1,340 tons burden, and 400 nominal horse-power. Her speed was somewhat over 12 miles per hour, and her successful voyages to and from Bristol and New York completely determined the rise of the existing gigantic steam service between Great Britain and the Continent of America, across the Atlantic, Indian, and Pacific Oceans.

It may be interesting to record that paddle steamers are sometimes driven by a paddle wheel at the stern; by paddle wheels placed between two hulls; or by more than the ordinary pair of wheels.

Stern wheel steamers are chiefly employed for shallow river and canal navigation.

Double-hull paddle steamers are represented by Patrick Miller's steamer run on Dalswinton Lake, N.B., in 1787–8; the Dover and Calais service steamers, "CASTALIA," built 1874 by the Thames Ironworks Company, Millwall; and the "CALAIS DOUVRES," built 1877 by A. Leslie, Hebburn, Newcastle.

Multiple wheel steamers are represented by the "COMET" 4-wheel paddle steamer, built 1811 by J. and C. Wood, Glasgow, and run on the Clyde; by the 4-wheel paddle steamer "TACHTALIA," built 1854 by J. and A. Blyth & Co., Limehouse, for service on the Danube; and the 4-wheel paddle steamer "BESSEMER," built 1875 by Earle's Shipbuilding Company, Hull, for the English Channel service.

PADDLE-WHEEL STEAMSHIPS.

55. WHOLE MODEL. The paddle-wheel steamer "EVELYN." Length 230 ft., breadth of beam 28 ft., draught of water with 1,000 bales of cotton on board, 7 ft. Tons 284 N.M.; horse-power 200. Speed at full power, 17 knots. Built in 1864 by Messrs. Randolph, Elder & Co., Glasgow.
Presented by the late Capt. Hugh Talbot Burgoyne, R.N. 1865.

56. HALF MODEL. The Peninsular and Oriental Company's paddle steamer "NYANZA." Nominal horse-power 450. Engines (oscillating) by J. and G. Rennie. Launched

3rd November 1864, by the Thames Iron Works Company, Millwall. Length 327 ft. 3 ins., breadth 36 ft. 2 ins., depth 27 ft. 6 ins. Tonnage register 2,082.

The Peninsular and Oriental Company. 1865.

57. HALF MODEL. Messrs. Jardine, Mathison & Co.'s paddle steamer "GLENGYLE," constructed for service in China and the navigation of the river Yangtzee. Tons 2,040. Horse-power 400 nominal. Designed and built by W. Denny & Brothers, Dumbarton.

Presented by Messrs. W. Denny & Brothers, Dumbarton, N.B. 1865.

58. WHOLE MODEL of the first iron steamers built on the Thames. The "LORD W. BENTINCK," "MAGNA," and "JUMNA," in 1832 for the Honourable East India Company, for the navigation of the River Ganges. Designed and built by Messrs. Maudslay, Sons, and Field.

Presented by Messrs. Maudslay, Sons, and Field. 1866.

59. WHOLE MODEL, rigged. The Cunard iron paddle steamer "SCOTIA." Built, 1861, for the British and North American (Cunard) Royal Mail Steam Packet Company by R. Napier & Sons, Glasgow.

Presented by Messrs. R. Napier & Sons, Glasgow. 1867.

Note.—The principal dimensions of the paddle steamship "SCOTIA" are:—Length 366 ft. all; breadth 47 ft. 6 ins.; tonnage, (builders' measurement) 4,050; load displacement 6,520 tons. Horse-power 1,000 nominal. Diameter of cylinders 100 ins., length of stroke 12 ft. The engines on the principle known as the side lever, were constructed by Messrs. R. Napier & Sons.

Diameter of paddle wheels 40 ft. Size of floats, 11 ft. 6 ins. by 2 ft.

The "SCOTIA" may be said to have been the last of the ocean-going paddle steamers for commercial purposes, screw propeller vessels having superseded them. It may therefore be interesting to add that the first steamer which crossed the Atlantic and traded regularly between England and America was the paddle steamer "GREAT WESTERN," engined by Messrs. Maudslay, Sons, and Field, in 1838. She was 1,340 tons burthen, and driven by side lever engines of 420 horse-power, having cylinders 74 ins. diameter and 7 ft. stroke. Her paddle wheels were 28 ft. diameter, and the floats, 28 in number, were 1 ft. 10 ins. wide. The wheels made 10 to 18 revolutions per minute. The boilers were 4 in number, with return flues, and the

working steam pressure in them was 5 lbs. on the square inch. The "GREAT WESTERN" was built of wood, by Patterson, of Bristol, and launched in 1837. She was broken up in 1856. Her length was 212 ft.; breadth 35 ft. 4 ins.; depth 23 ft. 2 ins. Her average speed was 9½ to 10 knots per hour.

60. WHOLE MODEL, rigged. The City of Dublin Steam Packet Company's paddle mail steamer "CONNAUGHT" running between Kingstown and Holyhead. Length 348 ft., width 35 ft., depth 20 ft. 3 ins., tonnage 2,039, nominal horse-power 720. Makers of the engines, which are on the oscillating principle, Messrs. Ravenhill, Salkeld, & Co., London. Diameter of cylinders 98 ins.; length of stroke 6 ft. 6 ins. The ship was designed and built by Messrs. John Laird, Sons, & Co., Birkenhead, and launched in 1860. Speed 21 statute miles per hour.

Lent by Messrs. Laird Brothers, Birkenhead. 1869.

Note.—The paddle steamers "LEINSTER," built by Samuda Brothers, London, and the "ULSTER" AND "MUNSTER," by Laird Brothers, Birkenhead, for the Kingstown and Holyhead service, in 1860, are still on daily duty after a complete overhaul and refit in 1885, in which year the paddle steamer "IRELAND" was added to the fleet, built of steel, by Laird Brothers, having a speed computed at 20 knots per hour, and engines on the compound oscillating cylinder construction of 6,000 indicated horse-power.

61. WHOLE MODEL. The Trinity House paddle steamer "GALATEA." Tons 507 B.M. Nominal horse-power 200. Launched in 1867. Built and engined by Messrs. Caird & Co., Greenock.

The Corporation of the Trinity House. 1869.

Note.—The oscillating engines are fitted with Caird & Co.'s expansion gear. The cylinders are 52 ins. diameter with stroke of 66 ins. The paddle-wheels have feathering floats. Her speed 14½ knots per hour. Two boilers with eight furnaces supply steam. The dimensions of the "GALATEA" are 230 ft. long, 26 ft. wide, and 13 ft. 10 ins. depth of hold.

62. HALF BLOCK MODEL of mail steamboat "DOVER," 1840. Paddle-wheel. Length 113 ft., breadth 21 ft., depth 9 ft. 10½ ins. 228 tons. 90 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—This was the first iron mail steamer, and was built for the Admiralty in 1840. She carried the mails between Dover and Calais for many years, and afterwards did good service on the coast of Africa.

63. HALF BLOCK MODEL of the "HELEN MCGREGOR," 1843, paddle steamer. Length 180 ft., breadth 26 ft., depth 15 ft. 573 tons. 223 horse-power.
Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Built for carrying passengers and cattle between Hull and Antwerp; one of the largest vessels of her class.

64. HALF BLOCK MODEL of mail boat "LORD WARDEN," 1847. Paddle-wheel. Length 160 ft., breadth 24 ft., depth 10 ft. 9 ins. 446 tons. 160 horse-power nominal.
Messrs. Laird Brothers. 1876.

Note.—Built for the South Eastern Railway Company in 1847, and is still running as one of their despatch boats between Folkestone and Boulogne.

65. HALF BLOCK MODEL of mail boat "CAMBRIA," 1848. Paddle-wheel. Length 196 ft., breadth 27 ft., depth 14 ft. 6 ins. 716 tons. 370 horse-power.
Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Built for the Chester and Holyhead Railway Company for their despatch service between Holyhead and Dublin, was lengthened in 1860, and is still running as a cattle boat.

66. HALF BLOCK MODEL of the "COUNTESS OF ELLESMERE," 1852. Paddle steamer. Length 160 ft., breadth 20 ft., depth 7 ft. 6 ins. 315 tons. 80 horse-power.
Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Fast paddle passenger steamer, formerly running on the Mersey, afterwards sold as a yacht to the Grand Duke Constantine of Russia.

67. WHOLE MODEL. Double ended paddle steamer for Channel service from France to England.
Lent by Messrs. A. and J. Inglis, Point House Ship Yard, Glasgow. 1877.

Note.—The whole model represents a paddle steamer designed by A. and J. Inglis to meet the requirements of Mr. John Fowler's, C.E., and others Channel ferry scheme, 1870. The steamer has an awning deck amidships, and is so constructed as to take on board a train of railway carriages at either end, and to carry mails and passengers across the English channel.

68. HALF MODEL. The Peninsular and Oriental Company's paddle-wheel steamship "MASSILIA." Built of iron, 1860, by Messrs. Samuda Brothers, London. Length 300 ft., breadth 36 ft., depth 24 ft. 6 ins. Tons B.M. 1,919, gross 1,640. She was fitted with oscillating paddle engines by Messrs. John Penn & Sons, Greenwich. Indicated

horse-power 1,730. Steam pressure in boilers 20 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

Note.—This paddle-wheel steamship was succeeded in 1883 by a new vessel, "MASSILIA," driven by the screw, built of steel, and engined and fitted out by Messrs. Caird & Co., Greenock. Her gross tonnage is 4,908. Her engine horse-power indicated 5,000. The working steam pressure at the boilers 90 lbs. per square inch.

For other models lent by the Peninsular and Oriental Company, see pages 40–46, 58, 190, 191, 260.

69. WHOLE MODEL. Paddle steamship "BRIGHTON." Newhaven and Dieppe service. Steel, built 1878; J. Elder & Co., Glasgow. Length 220 ft. 1 in., breadth 27 ft. 6 ins., depth 11 ft. 8 ins. Tons B.M. 819. Horse-power 300. J. Elder & Co., Engineers.

Lent by the London Brighton, and South Coast Railway Company. 1878.

70. PHOTOGRAPHS. Set of four. Paddle steamers "BORDEAUX," "MARSEILLES," and "BRIGHTON," Dieppe and Newhaven service; and screw steamship "HONFLEUR," Littlehampton and Honfleur trader.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

71. WHOLE MODEL. Light draft paddle steamer "JAVARY." The Amazon Steam Navigation Company. Built 1874. Laird Brothers, Birkenhead. Length 161 ft., breadth 28 ft., depth 10 ft. Tons 601. Load draught 6 ft. Oscillating cylinder compound engines. Horse-power 550 indicated.

Lent by Messrs. Laird Brothers, Birkenhead. 1879.

72. WHOLE MODEL. The paddle steamers "ROSE" and "SHAMROCK." London and North Western Railway Company. Built 1876. Laird Brothers, Birkenhead. Length 290 ft. 4 ins., breadth 32 ft., depth 16 ft. 7 ins. Tons 1,476. Load draught 10 ft. 8 in. Horse-power 3,000 indicated.

Lent by Messrs. Laird Brothers, Birkenhead. 1879.

73. HALF BLOCK MODEL. Paddle steamer, built of steel, 1879, for London and North Western Railway Company. Length 310 ft. Tons B.M. 1,623. Horse-power 3,200 indicated.

Lent by Messrs. Laird Brothers, Birkenhead. 1879.

74. HALF BLOCK MODEL. The iron paddle steamer "HANKOW." Built, 1873, by A. and J. Inglis. Length 308 ft., breadth 42 ft., depth 15 ft. 9 ins. Tons, gross, 3,073.

Lent by Messrs. A. and J. Inglis, Point House, Glasgow. 1881.

Note.—The "HANKOW" is constructed on American lines and principles. She has a single rocking beam engine with a cylinder 72 ins. diameter, and 14 ft. stroke. The paddle-wheels have fixed alternating half floats, and their diameter is 38 ft. Speed 13 knots per hour.

75. HALF BLOCK MODEL. The Clyde river passenger paddle steamer "BRODICK CASTLE." Built, 1878, by H. MacIntyre & Co., and engined by Messrs. W. King & Co. Length 207 ft. 6 ins., breadth 21 ft. 7 ins., depth 7 ft. 5 ins. Gross tons 243. Scale of model $\frac{1}{4}$ in. to 1 ft.

Lent by Messrs. H. MacIntyre & Co., Merksworth, Paisley. 1881.

Note.—The "BRODICK CASTLE" is fitted with direct-acting surface condensing diagonal engines, having two cylinders 38½ ins. diameter, and a stroke of 5 ft. 6 ins. She has two haystack upright multitubular boilers, each 11 ft. 3 ins. diameter, and 13 ft. 3 ins. high, working at 57 lbs. steam, per square in. Her iron wheels, 19 ft. 6 ins. in diameter, have feathering floats. Her engines are of 100 nominal horse-power, or 1,000 indicated horse-power. They make 43 revolutions per minute. The speed of paddle steamer "BRODICK CASTLE" is 17¼ miles per hour.

76. HALF BLOCK MODEL. High speed paddle steamer "THE BARROW EXPRESS."

Lent by the Barrow-in-Furness Shipbuilding and Engineering Company, Barrow-in-Furness, Lancashire. 1882.

Note.—This vessel was designed at Barrow about 1881–2, for high-speed service between Barrow-in-Furness and the Isle of Man. In 1885 the paddle steamer "MONA'S QUEEN," built of steel by the Barrow-in-Furness Shipbuilding and Engineering Co., was turned out complete. She runs between Liverpool or Fleetwood and the Isle of Man, and is one of the fastest vessels on the Isle of Man service. Her engines on the oscillating cylinder compound principle develop 5,000 indicated horse-power. Her boilers (four double-ended, of steel) supply steam at 85 lbs. per square in. Her feathering float wheels are 24 ft. in diameter, and have each 10 floats of steel.

77. FOUR HALF BLOCK MODELS of paddle steam boats on service between the Isle of Man and Liverpool.

1. "MONA'S ISLE." Length 330 ft., breadth 38 ft., depth 15 ft. Gross tonnage 1,500. Indicated horse-power 4,500.

2. "BEN-MY-CHREE." Length 310 ft., breadth 31 ft., depth 13 ft. 6 ins. Gross tonnage 1,030. Indicated horse-power 2,300.

3. "KING ORRY." Length 260 ft., breadth 29 ft., depth 14 ft. 6 ins. Gross tons 813. Indicated horse-power 1,800.

4. "SNAEFELL." Length 250 ft., breadth 29 ft., depth 14 ft. 6 ins. Gross tonnage 785. Indicated horse-power 1,800.

The Isle of Man Steam Packet Company, Douglas. 1884.

Note.—These steamers run between Liverpool and the Isle of Man, and have done effective service for many years past.

78. WHOLE MODEL. Paddle steamer "ALBATROSS." Length 140 ft., breadth 19 ft., depth 8 ft. 3 ins. Driven by side-lever engines of 53 nominal horse-power. Speed 13 knots.

Lent by Messrs. Hepple & Co., Wapping Street, South Shields. 1882.

For another model lent by Hepple & Co., see page 54.

79. ORIGINAL MODEL of a double-hull ship fitted with paddle-wheels in 1787 by Patrick Miller, of Dalswinton, N.B.

Transferred from the Patent Museum. 1885.

Note.—The model represents a sailing vessel having two complete hulls securely held together. Between the hulls are placed two paddle-wheels, one behind the other, driven by manual labour. The model also represents the vessel as having five masts, square rigged, and double rudders.

A coloured engraving of another and later triple-hull vessel, "THE EDINBURGH," designed by Mr. Miller, and built at Leith, 1786, to be propelled by paddle-wheels, will be found in the collection, *see* page 285. Both these manual-labour paddle-wheel ships were abandoned in favour of steam power by Mr. Miller, who in 1788, ran on Dalswinton Lake, a double-hull boat with two paddle-wheels, one behind the other between the hulls, driven by a steam-engine constructed by William Symington, at Low Calton, Edinburgh.

80. WHOLE MODEL. Fitted with its working engine and boiler. The stern-wheel steamer "CHARLOTTE DUNDAS," 1801. Built by A. Hart at Grangemouth and engined by William Symington for service on the Forth and Clyde Canal.

Lent by Mr. W. Rankine, New Brompton, Kent. 1888.

Note.—The "CHARLOTTE DUNDAS," completed in 1802, was 56 feet long, 18 feet beam, and 8 feet deep, and propelled by a single paddle-wheel at the stern, boxed or housed in. At the after end the hull was divided, forming a cavity 4 ft. wide and 12 ft. long, in which the paddle-wheel worked. It was driven by a crank on its shaft and a connecting rod to the engine, which was a horizontal direct-acting condensing engine of 10 nominal horse-power, with a cylinder 22 ins. in diameter and a stroke of 4 ft. The air-pump was vertical and driven by a bell-crank. It will be observed that the engine was placed on the deck. The model also shows the position of the steering wheel at the fore part of the steamer, Symington's arrangement, in use at the present day. The model of the "CHARLOTTE DUNDAS" is said to be made from parts of the original vessel. With the model are exhibited two drawings showing longitudinal section of—

1. The "CHARLOTTE DUNDAS."
2. The Original Steamboat of Patrick Miller and William Symington, 1788.

Another contemporary steamer was the "INDUSTRY," built by Fyfe at Fairlie, 1814, and run on the Clyde till 1873. Her hull still floats on that river; her engines, by Caird & Co., 1826, were exhibited at the Glasgow International Exhibition of 1888.

80A. ORIGINAL WHOLE MODEL of the Paddle steamboat "COMET." Built on the Clyde at Port Glasgow by John Wood, for Mr. Henry Bell, 1811. Length 42 ft., breadth 11 ft., depth 5 ft. 6 ins.

Messrs. John Reid & Co., Port Glasgow. 1876.

Note.—In August 1812 the steam passage boat "COMET" began to run on the Clyde between Glasgow, Greenock, and Helensburgh, with passengers only. She was advertised to leave the Broomielaw on Tuesdays, Thursdays, and Saturdays, at an hour suitable to the tide, and to return from Greenock on Mondays, Wednesdays, and Fridays. The fares were 4*s.* for the best cabin, and 3*s.* for the second, and no gratuities to the vessel's servants were allowed. The boat was driven by a condensing steam engine of 4 horse-power, constructed at Glasgow. At first she had two pairs of paddle-wheels, *i.e.*, two wheels on each side of the vessel. These were subsequently reduced to one wheel only on each side of the hull.

81. WHOLE MODEL. The steamship "GREAT EASTERN." Built 1857.

Contributed by Messrs. J. Scott Russell & Co. 1857.
Transferred from the Patent Museum. 1885.

Note.—This model represents the "GREAT EASTERN" as completed and painted outside, originally.

82. WHOLE BLOCK MODEL. The steamship "GREAT EASTERN." Built 1857.

Contributed by Messrs. J. Scott Russell & Co. 1857.
Transferred from the Patent Museum. 1885.

Note.—This model represents lines of least resistance, and horizontal lines of the ship's hull.

For particulars of the "Great Eastern" steamship, see page 134.

83. WHOLE BLOCK MODEL. Paddle steamboat "BARON OSY." Tons, 792. Horse power, 260. Built of iron, 1855, for the London and Antwerp trade by John Scott Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

Note.—There have been three "BARON OSY'S" built for the passenger and goods trade between London and Antwerp. The first was turned out about 1840; the second, represented by this block model, was built 1855; the third, and present running vessel, was built 1875. She was built by Mitchell & Co., Low Walker, Newcastle, and belongs to Antwerp.

84. WHOLE BLOCK MODEL. Paddle steamboats "LYONS" and "ORLEANS." Tons, 415. Horse-power, 160. Built of iron, 1856, for the London, Brighton, and South Coast Railway Company's service between Newhaven and Dieppe, by John Scott Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

Note.—The Newhaven and Dieppe service has been re-furnished of late with larger and more powerful steamers than those represented by this model, which, however, were celebrated in their day for high speed and efficiency.

85. WHOLE BLOCK MODEL. Paddle steamboat "WAVE QUEEN." Tons, 250. Horse-power, 80. Built of iron, 1852, by John Scott Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

Note.—The "WAVE QUEEN," at the time she was launched, was the narrowest sea-going steamer for her length ever built, being 210 ft. long, and 15 ft. beam, one-fourteenth of her length. She was designed by the late John Scott

Russell, F.R.S., with a view of testing to its utmost practical limit his calculated wave line system of construction for ships and steamers. The "WAVE QUEEN" had great speed, though her engine-power of 80 nominal horse-power was so small.

CLASS I.

Mercantile Marine.—Screw Propeller Steamships.

NOTE ON SCREW STEAMSHIPS.

In 1681, Dr. Robert Hook, of the Royal Society, and of Gresham College, illustrated the power of a screw form of propellor to drive boats, and as he maintained even large ships. From this date until 1836, although many devices are recorded as appearing in France, Britain, and America, for propelling vessels by the screw, nothing actually practical seems to have been accomplished.

In 1836, the late Francis Pettit Smith secures a patent for a screw propeller of his design, and in 1837 his screw, driven by steam power, was fitted into a small boat, 34 ft. long, 6 ft. 5 ins. broad, and 4 ft. draught of water. On 29th September 1837 the boat ran from Gravesend to Margate, with an average speed of eight miles per hour.

In 1838, the celebrated screw propellor vessel "ARCHIMEDES" appeared. She was built at Blackwall by Henry Wimshurst. She was 125 ft. long, 21 ft. 10 ins. broad, 13 ft. hold depth, draught of water 9½ ft. Her steam-engine power was 80 horse nominal. Her propeller, a single thread screw, made one comple turn on its axis.

In 1840 numbers of experiments were made with the "ARCHIMEDES" screw propeller ship. She ran many successful journeys against the Dover and Calais mail service paddle steamers of the time.

In 1839, another vessel, the "NOVELTY," was built at Blackwall by Mr. Wimshurst, for propulsion by the screw.

In 1840, the "GREAT NORTHERN," screw steamer, was built in Ireland, at Derry, under Captain Coppin.

Three years later appeared the "RATTLER," built by the Admiralty, five guns, 200 nominal horse-power, the first screw propeller war vessel in Her Majesty's Navy. She was accompanied on the Navy List by the "MERMAID," afterwards named "DWARF," built by Ditchburn and Mare, engined and fitted by Rennie with a screw propeller devised by Mr. George Rennie, 1840. The speed of the "DWARF" was 12 miles per hour. After exhaustive trials with the

"RATTLER," engined by Maudslay and Field, and the "DWARF," the Admiralty determined to apply the screw propeller to some of Her Majesty's existing ships-of-war; and the "AJAX," "BLENHEIM," and "HOGUE," became the first screw propeller line-of-battle steam ships in Her Majesty's service.

In 1845, from an official return sent into Parliament, it appeared that there were five screw propeller steamboats at work at Liverpool. In 1846 there were 15, and in 1847 28. On the Thames in 1847, screw steamers were working from London to Holland, named the "CITY OF LONDON," and "CITY OF ROTTERDAM." They were 272 tons burden, 30 horse-power nominal, with a speed of 7·92 miles per hour. These vessels were matched by two other screw steamers, the "LORD JOHN RUSSELL," and the "SIR ROBERT PEEL," each of 320 tons burden, 40 horse-power nominal, with a speed of 8·25 miles per hour.

The rise in favour of the screw propellor for driving steamships in lieu of paddle-wheels, from this time asserts itself with great rapidity. In such a short notice as space permits it is impossible to mention a tithe of the strides made in screw propeller vessels after the appearance and success of Brunel's celebrated vessel the "GREAT BRITAIN," built of iron, 1843, under him at Bristol by Patterson, her tonnage being 3,5C0, and her engine-power furnished by Boulton and Watt, of Soho, Birmingham, 1,000 horse-power nominal. The "GREAT BRITAIN" crossed the Atlantic successfully for many years from Bristol to New York and *vice versa* as a cargo and passenger steamship. Her average speed was about 10 knots per hour.

Screw propeller steamships are now classed under the following heads:—Single screw propellor vessels, *i.e.*, having one propellor only aft; twin-screw propellor vessels, *i.e.*, having two propellors aft working independently, and fitted one on each side of the dead wood; triple or three screw propeller vessels having a pair of independent screws aft, and a single screw at the fore foot, or three independent screw propellers aft; quadruple or four-screw propeller vessels, having a pair of screws aft and forward on the port and starboard hand, each pair driven simultaneously but quite independently, by a set of engines devoted to the purpose.

Twin-screw steamships appear to have been first constructed about 1857 by J. and G. Rennie, London; by Dudgeon, London, in 1863, who built the "FAR EAST" steamship, having twin-screws but small engine power. In 1881 a fleet of ocean twin-screw steamships was started for service at Liverpool. The ships were built at Glasgow by Dobie & Co. Their boilers, engines, and machinery were furnished by J. Howden and Son, Glasgow. The vessels are known as the "HILL" line of twin-screw steamships from their names "NOTTING HILL," "TOWER HILL," "LUDGATE HILL," and so on. In 1888 Messrs. J. and G. Thomson, Clyde Bank,

Glasgow, completed, for the service of the Inman line steamships, Liverpool, the twin-screw steamships, built throughout of steel, "CITY OF NEW YORK" and "CITY OF PARIS," having a total engine power each of 20,000 horses indicated. Messrs. Harland and Wolff, at Belfast in the same year, completed for the White Star line of steamships, Liverpool, two vessels built throughout of steel, and fitted with twin screws. The collective indicated horse-power of each approaches 20,500. In the Royal Navy twin-screw propellers have been fitted to heavily armoured ships of war for some years past, and the system continues in favour. Steamers with more than two screws have been constructed by Howden and Sons; J. Elder & Co.; J. and G. Thomson, Glasgow; Flannery and Fawcus, Liverpool; and others.

SCREW PROPELLER STEAMSHIPS.

86. WHOLE MODEL. Scale ¼ in. to 1 ft. The Montreal Ocean Steamship Company's screw steamers "HIBERNIAN" and "NORWEGIAN." Designed and built by W. Denny & Brothers, Dumbarton. This model shows on the port side the internal arrangement, cabins, engine-room space, &c.

Lent by Messrs. W. Denny & Brothers, Dumbarton, N.B. 1865.

Note.—The dimensions of the steamships "HIBERNIAN" and "NORWEGIAN" are:—Length of keel and fore rake 292 ft., breadth, beam, moulded, 37 ft. 9 ins.; depth, moulded, 33 ft. Tonnage o.m. 2,041. Horse-power 400, nominal.

87. WHOLE MODEL, rigged. Scale ¼ in. to 1 ft. The Inman line screw steamer, "CITY OF PARIS," of the Liverpool, New York, and Philadelphia Steam Shipping Company (*Inman line.*) Tons 2,740. Nominal horse-power 450. Launched December 1865.

Presented by Mr. William Inman, the Inman Company, Liverpool. 1866.

Note.—The screw steamship "CITY OF PARIS" of the Inman line of Atlantic steamers, was built of iron and fitted out in 1866 by Messrs. Tod and MacGregor of Glasgow, now D. and W. Henderson & Co. Her dimensions are:—Length 397 ft., beam 40 ft. 4 ins., depth 26 ft. 2 ins., tonnage B.M. 2,875. Diameter of her engine cylinders 82 ins. Length of stroke 3 ft. 6 ins.

This ship made a remarkable voyage for speed across the Atlantic from New York to Liverpool in (March) 1869, in company with the iron screw steamship "RUSSIA," of the Cunard line. The "RUSSIA" was built in 1867 by Messrs. J. and G. Thomson of Glasgow, and is rather larger than the

"CITY OF PARIS," being 3,100 tons B.M. She has engine cylinders 86 ins. in diameter, with a stroke 3 ft. 10 inches.

In 1888, a new "CITY OF PARIS," of 10,500 tons, was built of steel, engined and fitted out by Messrs. J. and G. Thomson, Clydebank, Glasgow, for the Inman line. She is propelled by twin screws, and will attain a speed of 20 knots per hour. A sister vessel the "CITY OF NEW YORK," constructed and fitted out by the same shipbuilders for the same service, was also completed about the same time. Both twin screw steamships are built with the most recent and approved methods for safety, economy, and comfort.

88. WHOLE MODEL of the iron screw steamer "MEDWAY." Tons 1,464, nominal horse-power 250. Designed and built about 1865, by Messrs. Oswald & Co., Sunderland.

Lent by Messrs. Oswald & Co., Sunderland. 1867.

Note.—This steamer was employed, in conjunction with the "GREAT EASTERN" steamship, in laying the Atlantic telegraph cable, 1866.

89. MODEL of an iron screw steamer, built and designed by Messrs. Oswald & Co., for the Baltic or Mediterranean trade.

Lent by Messrs. Oswald & Co., Sunderland. 1867.

Note.—The principal dimensions of this trading steamer are :—Length over all 206 ft., breadth, extreme, 28 ft. 10 ins., depth 18 ft. 4 ins., tonnage, B.M., 806. Register gross 750, draft, light 7 ft., laden 16 ft., horse-power 100 nominal, diameter of cylinders 36 ins., stroke 26 ins.

90. HALF MODEL. The Peninsular and Oriental Company's screw steamer "GOLCONDA." Tons 1,909. Nominal horse-power 400. Launched 2nd December 1863 by the Thames Iron Works Company, Millwall. Length 314 ft. 3 ins., breadth 38 ft. 3 ins., depth 26 ft. 6 ins. Her engines, by Messrs. Humphrys and Tennant, are constructed on Wolf's double-cylinder system.

Presented by the Peninsular and Oriental Company. 1865.

91. HALF MODEL of the Peninsular and Oriental Company's screw steamer "DELHI." Tons 1,898. Horse-power, nominal, 400. Makers of the engines, Messrs. Ravenhill, Salkeld & Co. Launched September 1864. Built by Messrs. Money Wigram & Sons.

Lent by the Peninsular and Oriental Steam Navigation Company. 1868.

92. HALF MODEL of the Peninsular and Oriental Company's screw steamer "CHARKIEH." Tons 1,615. Horse-

power 350. Makers of the engines, Messrs. J. and G. Rennie. Launched December 1864. Built by the Thames Iron Works Company, Limited.

Lent by the Peninsular and Oriental Steam Navigation Company. 1868.

93. HALF MODEL of the Peninsular and Oriental Company's screw steamer "DAKAHLIEH." Tons 1,553. Horse-power 350. Makers of the engines, Messrs. J. and G. Rennie. Launched February 1865. Built by Messrs. Money Wigram & Sons.

Lent by the Peninsular and Oriental Steam Navigation Company. 1868.

94. HALF MODEL of the Peninsular and Oriental Company's screw steamer "TANJORE." Tons 1,971. Horse-power 400. Makers of the engines, Messrs. Ravenhill, & Co. Launched April 1865. Built by the Thames Iron Works Company, Limited.

The Peninsular and Oriental Steam Navigation Company. 1868.

95. HALF MODEL of the Peninsular and Oriental Company's screw steamer "SURAT." Tons 2,578. Horse-power, 500. Launched March 1866. Built and engined by Messrs. C. A. Day & Co., Southampton.

Lent by the Peninsular and Oriental Steam Navigation Company. 1868.

96. WHOLE MODEL. The Peninsular and Oriental Company's screw steamship "POONAH." Built of iron, 1862, by the Thames Iron Works Company, London. Length 315 ft., breadth 41 ft., depth 30 ft. Tons, 2,152. The engines were horizontal 4 cylinder, indicating 2,356 horse-power. Steam pressure in boilers, 25 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company, 122, Leadenhall Street, E.C. 1878.

Note.—In 1875 the Peninsular and Oriental Company's screw steamer "POONAH" was lengthened amidships by Mr. James Laing, Sunderland, making her: Length 395 ft., breadth 41 ft. 8 ins., tons, B.M., 3,147, gross 3,130. New compound inverted direct-acting surface-condensing engines, of 2,600 indicated horse-power were fitted by Messrs R. and W. Hawthorn, Leslie & Co. Newcastle. Steam pressure in boilers, 70 lbs. per square inch.

97. HALF MODEL. The Peninsular and Oriental Company's screw steamships "KHIVA" and "KASHGAR." Built of iron, 1874, by Mr. James Laing, Sunderland. Length 360 ft., breadth 36 ft. 6 ins., depth 29 ft. 3 ins. Tons, B.M., 2,396, gross 2,621. The engines are compound inverted direct acting and surface-condensing. They were fitted by Messrs. R. and W. Hawthorn, Leslie & Co., Newcastle. Indicated horse-power 2,200. Pressure of steam in boilers, 70 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

98. HALF MODEL. The Peninsular and Oriental Company's screw steamships "CATHAY" and "HYDASPES." Built of iron, 1872, by Messrs. Denny Brothers, Dumbarton. Length 360 ft., breadth 39 ft., depth 31 ft. 3 ins. Tons, B.M., 2,723, gross 2,984. The engines, fitted by Messrs. Denny & Co., Dumbarton, are compound inverted direct-acting surface-condensing. Indicated horse-power 2,500. Steam pressure in boilers, 65 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

99. HALF MODEL. The Peninsular and Oriental Company's screw steamship "DELHI." Built of iron, 1864, by Messrs. Wigram & Sons, London. Length 295 ft., breadth 38 ft., depth 29 ft. Tons, B.M., 2,090, gross 2178. The engines were fitted by Messrs. Ravenhill, Salkeld & Co., London, and are horizontal tandem 4-cylinder compound direct-acting, with surface-condensers. Indicated horse-power 2,286. Steam pressure in boilers. 25 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

100. HALF MODEL. The Peninsular and Oriental Company's screw steamship "CHINA." Built of iron, 1855, by Messrs. Laird Brothers, Birkenhead. Length 265 ft., breadth 36 ft., depth 32 ft. Tons, B.M., 1,692, gross 2,010. Messrs. Humphrys, Tennant & Co., Deptford, fitted new engines, 1866, which are inverted direct-acting, and 400 nominal horse-power, with a steam pressure in boilers of 24 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

101. HALF MODEL. The Peninsular and Oriental Company's screw steamship "TANJORE." Built of iron, 1865,

by the Thames Iron Works Company, London. Length 300 ft., breadth 38 ft., depth 29 ft. Tons, B.M., 2,129, gross 2,263. New engines were fitted by Mr. James Howden, Glasgow, 1876. They are inverted tandem 4-cylinder compound direct-acting, with surface-condensers, and indicate 2,000 horse-power. Steam pressure in boilers 61 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

102. HALF MODEL. The Peninsular and Oriental Company's screw steamships "TEHERAN" and "THIBET." Built of iron, and engined, 1874, by Messrs. Gourlay Brothers & Co., Dundee. Length 360 ft., breadth 36 ft., depth 29 ft. Tons, B.M., 2,333, gross 2,588. Both vessels are fitted with inverted compound surface-condensing direct-acting engines, each indicating 2,000 horse-power. Steam pressure in boilers 65 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

103. HALF MODEL. The Peninsular and Oriental Company's screw steamship "ZAMBESI." Built of iron, and engined, 1873, by Messrs. Barclay, Curle, & Co., Glasgow. Length 330 ft., breadth 36 ft. 6 ins., depth 28 ft. 6 ins. Tons, B.M., 2,183, gross 2,431. She is fitted with compound inverted direct-acting surface-condensing engines, indicating 1,600 horse-power. Steam pressure in boilers 60 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

104. HALF MODEL. The Peninsular and Oriental Company's screw steamships "MALWA" and "BOKHARA." Built of iron, and engined, 1873, by Messrs. Caird & Co., Greenock. Length 360 ft. 10 ins., breadth 39 ft., depth 31 ft. 3 ins. Tons, B.M., 2729. The engines are inverted compound surface-condensing and direct-acting, indicating 2,500 horse-power. Steam pressure in boilers 60 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

105. HALF MODEL. The Peninsular and Oriental Company's screw steamship "INDUS." Built of iron, 1871, by Messrs. Denny Brothers, Dumbarton. Length 360 ft., breadth 40 ft., depth 36 ft. 2 ins. Tons, B.M., 2,859, gross 3,462. The engines, constructed by Messrs. Denny & Co. Dumbarton, are compound inverted surface-condensing

direct-acting, and indicate 2,700 horse power. Steam pressure in boilers 65 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

106. HALF MODEL. The Peninsular and Oriental Company's screw steamship "COLOMBO." Built of iron, and engined, 1853, by Messrs. R. Napier and Sons, Glasgow. Gross tons 1,864. Her engines were beam engines, geared to screw shaft.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

Note.—The "COLOMBO," S.S. was lengthened in 1859, making her 2,127 gross register tons; her engines, on the same principle as in 1853, indicating 1,538 horse-power. Ship's lengthened dimensions: Length 320½ ft., breadth 37 ft., depth 29 ft.

107. HALF MODEL. The Peninsular and Oriental Company's screw steamships "VENETIA," "LOMBARDY," "GWALIOR," and "NIZAM." Built of iron, 1873, by Messrs. Denny Brothers, Dumbarton. Length 350 ft., breadth 38 ft., depth 29 ft. 9 ins. Tons, B.M., 2,515, gross 2,726. The engines, constructed by Messrs. Denny & Co., Dumbarton, are inverted compound surface-condensing direct-acting, and indicate 2,500 horse-power. Steam pressure in boilers 60 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

108. HALF MODEL. The Peninsular and Oriental Company's screw steamship "BANGALORE." Built of iron, 1867, by Messrs. Denny Brothers, Dumbarton. Length 305 ft. 3 ins., breadth 38 ft., depth 28 ft. Tons, B.M., 2,169, gross 2,342. She was fitted with inverted surface-condensing direct-acting engines by Messrs. Denny & Co., Dumbarton. Indicated horse-power 2,200. Pressure of steam in boilers 22 lbs. per square inch.

The Peninsular and Oriental Steam Navigation Company. 1878.

109. HALF MODEL. The Peninsular and Oriental Company's screw steamship "TRAVANCORE." Built of iron, 1868, by Mr John Key, Kirkcaldy. Length 280 ft., breadth 35 ft. 6 ins., depth 29 ft. 3 ins. Tons, B.M., 1,734, gross 1,900. Her engines, constructed by Messrs. Humphrys, Tennant, & Co., Deptford, are horizontal direct-acting,

indicating 1,428 horse-power. Steam pressure in boilers 24 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

110. HALF MODEL. The Peninsular and Oriental Company's screw steamship "ELLORA." Built of iron, 1855, by Messrs. Laird Brothers, Birkenhead. Length 261 ft., breadth 36 ft. 2 ins., depth 26 ft. 9 ins. Tons, B.M., 1,665, gross 1,727. Her engines, constructed by Messrs. J. and G. Rennie, London, are horizontal direct-acting and indicate 1,055 horse-power. Pressure of steam in boilers 20 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

111. HALF MODEL. The Peninsular and Oriental Company's screw steamship "SIMLA." Built of iron, and engined, 1854, by Messrs. Tod, Macgregor, & Co. (now Messrs. D. and W. Henderson & Co.), Glasgow. Length 325 ft., breadth 39 ft., depth 29 ft. Tons, B.M., 2,430, gross 2,441. Her engines were steeple, geared, indicating 1,766 horse-power. Steam pressure in boilers 16 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

112. HALF MODEL. The Peninsular and Oriental Company's screw steamship "DECCAN." Built of iron, 1868, by Messrs. Denny Brothers, Dumbarton. Length 345 ft., breadth 42 ft. depth 32 ft. 6 ins. Tons, B.M., 3,001, gross 3,429. She was fitted by Messrs. R. and W. Hawthorn, Leslie, & Co., 1875, with new inverted surface-condensing direct-acting engines, indicating 2,600 horse-power. Steam pressure in boiler 68 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

113. HALF MODEL. The Peninsular and Oriental Company's screw steamship "CANDIA." Built of iron, 1854, by Messrs. C. J. Mare & Co., London. Tons, gross, 1,961. She was fitted with trunk engines, geared.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

Note.—The S.S. "CANDIA" was lengthened in 1857, by Laird Brothers, making her length 310 ft., breadth 40 ft., depth 28 ft. 9 ins. Tons, B.M., 2,434, gross 1,982. New

trunk, geared engines were fitted to her, indicating 1,490 horse-power, with 20 lbs. steam pressure in boilers.

114. HALF MODEL. The Peninsular and Oriental Company's screw steamship "HINDOSTAN." Built of iron, 1869, by Messrs. C. A. Day & Co., Southampton. Length 345 ft., breadth 42 ft., depth 33 ft. Tons, B.M., 3,001, gross 3,186. Her engines, constructed by Messrs. Day, Summers & Co., Southampton, are inverted direct-acting, indicating 3,194 horse-power. Steam pressure in boiler 53 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company. 1878.

115. HALF MODEL. The Peninsular and Oriental Company's screw steamship "SURAT." Built of iron, 1866, by Messrs. C. A. Day & Co., Southampton. Tons, gross, 2,578. Her engines, constructed by Messrs. Day, Summers, & Co., Southampton, were horizontal direct-acting, indicating 2,516 horse-power. Steam pressure in boilers 26 lbs. per square inch.

Lent by the Peninsular and Oriental Steam Navigation Company, 122, Leadenhall Street, E.C. 1878.

Note.—In 1874 the S.S. "SURAT" was lengthened, making her gross tonnage 3,042. She was fitted with new engines on the compound system, indicating 2,855 horse-power, with a boiler working pressure of 75 lbs. steam per square inch.

For other models lent by the Peninsular and Oriental Company, see pages 31, 58, 190, 191, 260.

116. WHOLE MODEL. The West India and Pacific Steam Shipping Company's screw steamer "BOLIVAR," Built 1862 by Messrs. Richardson, Duck, & Co., Stockton-on-Tees. Length 240 ft., breadth 32 ft. 5 ins., depth 19 ft. 17 ins. Tons 1,250. The engines were fitted by Mr. J. C. Thompson, Newcastle-on-Tyne, and are inverted direct-acting, with cylinders 49 ins. in diameter, 20 ins. stroke, 200 nominal horse-power.

Lent by the West India and Pacific Steam Shipping Company. 1868.

117. WHOLE MODEL. The West India and Pacific Steam Shipping Company's screw steamer "VENEZUELA." Built 1865, by Messrs. Jones, Quiggin, & Co., Liverpool. Length 259 ft. 5 ins., breadth 32 ft. 1 in., depth (extreme)

28 ft. 9 ins. Tons 1,682. Engines of 220 nominal horse-power were fitted by Messrs. James Jack & Co., Liverpool.

Lent by the West India and Pacific Steam Shipping Company. 1868.

118. WHOLE MODEL. The screw steamship "FARADAY," constructed for Messrs. Siemens Brothers specially for carrying and laying submarine electric telegraph cables.

The late Dr. C. W. Siemens. 1874.

Note.—The "FARADAY" was built entirely of iron, in 1874, by W. Mitchell & Co., Low Walker, Newcastle. Her length is 361 ft., breadth 52 ft., depth in hold 36 ft., draught, laden, 26 ft. Registered tonnage 4,908. Carrying capacity 5,850 tons. She is double-bottomed and flat.

The ship has three cable tanks, each 27 ft. deep. Two are of 45 ft. diameter, and one is of 37 ft. In these tanks the telegraph cable lies in water and coiled round a hollow cone of iron reaching from the bottom to the top of them. To keep the ship at a uniform draught of water while paying out the cable, these cones carry water from the sea, as well as the tanks and her double bottom; the ship is thus uniformly ballasted. Her engines, on the compound system with surface condensers, drive twin screws. They are each of 250 horse-power, nominal. The high-pressure cylinders are 39 ins. diameter, the low pressure 68 ins. The stroke is 48 ins. The engines were built by T. Clark & Co., Newcastle.

Six boilers, containing the total heating surface of 9,000 square ft., supply steam. The screw propellers are each 16 ft. in diameter.

119. WHOLE MODEL, full rigged, on a $\frac{1}{4}$ in. to 1 ft. scale. The Glen Line Company's screw steamship "GLENARTNEY," built of iron, 1874, by the London and Glasgow Shipbuilding and Engineering Company, Glasgow. Compound inverted cylinder engines of 330 nominal horse-power.

Messrs. MacGregor, Gow, & Co. 1874.

Note.—In 1874, the steamship "GLENARTNEY" ran from China (Woosung) to London, *viâ* Suez Canal, in 44 days.

The model represents a fleet of steamers employed between London and China direct, *viâ* Suez Canal. Dimensions, about 330 ft. long, 35 ft. beam, 25 ft. deep. Tons, gross, 2,106. Horse-power 330 nominal.

A still larger and more powerful vessel, the "GLENEAGLES," was launched in 1876–7 for the same service.

120. HALF BLOCK MODEL. The screw steamships "MATABAN" and "IRRAWADDY." The British and Burmese Steam Navigation Company. Keel length 340 ft., breadth

36 ft., depth 28 ft. Tons, register, 2,514. Built 1874, by W. Denny & Brothers.

Lent by Messrs. W. Denny & Brothers, Dumbarton. 1874.

121. HALF BLOCK MODEL. The screw steamships "VENETIA," "LOMBARDY," "GWALIOR," and "NYZAM." The Peninsular and Oriental Steam Navigation Company. Keel length 350 ft., breadth 38 ft., depth 28 ft. 9 ins. Tons 2,513. Built 1873, by W. Denny & Brothers.

Lent by Messrs. W. Denny & Brothers, Dumbarton. 1874.

122. HALF BLOCK MODEL. The screw steamships "CATHAY" and "HYDASPES." Keel length 360 ft., breadth 39 ft., depth 31 ft. 3 ins. Tons, o.m. 2,723. Built 1872, by W. Denny & Brothers.

Lent by Messrs. W. Denny & Brothers, Dumbarton. 1874.

123. HALF BLOCK MODEL. The Royal Mail screw steamship "BOYNE." Keel length 358 ft. 6 ins., breadth 40 ft. 5 ins., depth 34 ft. 6 ins. Tons, o.m., 2,882. Built 1871, by W. Denny & Brothers.

Lent by Messrs. W. Denny & Brothers, Dumbarton. 1874.

124. HALF BLOCK MODEL. The Atlantic screw steamers "NEVADA" and "IDAHO." Liverpool and New York line. Built 1868, for the Liverpool and Great Western Steamship Company, by the Palmer's Shipbuilding Company, Limited. Length 352 ft., breadth 43 ft., depth 30 ft. Tonnage gross 3,132, horse-power 440 nominal, speed 13 knots per hour. Scale $\frac{1}{8}\frac{1}{6}$ full size.

Palmer's Shipbuilding Company, Limited, Newcastle-on-Tyne. 1874.

125. HALF BLOCK MODEL of the "ROBERT F. STOCKTON," 1838. Iron screw steamer. Length 63 ft. 5 ins., breadth 10 ft., depth 7 ft. Tons, 33. Horse-power, 30.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—One of the first screw steamers ever built, fitted with Ericsson's screw propeller.

The propeller was unshipped for the voyage made under canvas from Liverpool to New York, where she was employed for many years as a tug boat.

126. HALF BLOCK MODEL of the "FOREBUNNER" 1852. Iron screw steamer. Length 161 ft. 6 ins., breadth 22 ft., depth 11 ft. 4½ ins. Tons 381. Horse-power 50.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Built for McGregor Laird, Esq., the founder of the African Royal Mail Steam Navigation Company, of which she was the pioneer vessel.

127. HALF BLOCK MODEL of the "NUBIA," 1854. Iron screw steamer. Length 292 ft., breadth 39 ft., depth 27 ft. 9 ins. Tons 2,173. Horse-power 450.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Type of mail and passenger screw steamer of her date. Built for the Peninsular and Oriental Steam Navigation Company, and still (1876) carrying the mails in their service.

128. HALF BLOCK MODEL of the "AFRICA," 1871. Iron screw steamer. Length 285 ft., breadth 34 ft., depth 23 ft. 3½ ins. Tons 1,627. Horse-power 200.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—One of the early steamers of the African Royal Mail Company, for same service as "FOREBUNNER," built 1852.

129. HALF BLOCK MODELS of the "CORCOVADO," "PUNA," and "BRITANNIA," 1872. Iron screw steamer. Length 375 ft., breadth 43 ft., depth 33 ft. 9 ins. Tons 3,434. Horse-power 600.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Type of mail and passenger screw steamer of date. Built for the mail and passenger service of the Pacific Steam Navigation Company. The "CORCOVADO" made her first voyage from Liverpool to Callao, 11,000 knots, in 33½ days, equal to a mean speed of 13·54 knots.

130. HALF BLOCK MODEL of the screw steamship "SIR JOHN LAWRENCE." Embodying to a considerable extent the form of least resistance, designed by Michael Scott, in conjunction with the late Andrew John Robertson. The performance of this ship was excellent.

Lent by Mr. Michael Scott, F.R.S.E., London. 1876.

131. MODEL of the solid of LEAST RESISTANCE, by the late Andrew John Robertson, dated 1861.

Lent by Mr. Michael Scott, F.R.S.E., London. 1876.

132. HALF BLOCK MODEL. The iron screw steamship "DEVONIA." Built 1876 by the Barrow Shipbuilding Company.

Lent by the Barrow Shipbuilding and Engineering Company, Barrow-in-Furness. 1877.

Note.—The screw steamer "DEVONIA" was built for the Anchor Line of steamships for passenger trade between Great Britain and America.

Her length is 400 ft. between perpendiculars. Tonnage 4,500. The ship was built and engined in 1877 by the Barrow Iron Shipbuilding Company, Barrow-in-Furness, for trade between the port of Barrow and New York.

133. HALF BLOCK MODEL of an iron passenger and cargo steamer for Atlantic trade.

Lent by Messrs. J. and G. Thomson, Clyde Bank Foundry, Glasgow. 1877.

Note.—The model represents a proposed iron screw steamship for ocean service of the following dimensions: length 420 ft., beam 45 ft., depth 35 ft., tons, gross, 4,858. Horse-power indicated 4,500. Designed 1877.

134. WHOLE MODEL of an ocean-going screw steamship designed for the service of the Eastern Telegraph Company by E. W. Briscoe.

Mr. E. W. Briscoe. 1877.

Note.—This ship was designed for picking up and repairing ocean telegraph cables. Her principal dimensions are, length between perpendiculars 300 ft., breadth of beam 40 ft., extreme depth from top of keel to underside of deck 20 ft. Tonnage o.m. 2,349. The model is on a scale of $\frac{1}{4}$ in. to 1 ft.

135. WHOLE MODEL. Scale $\frac{1}{4}$ in. to 1 ft. The iron screw steamship "GREAT BRITAIN." Designed 1840 by Brunel, and built at Bristol, 1841–3, by Patterson & Co. Tons 3,500. Horse-power 1,000. Engines, boilers, and machinery designed and constructed by Boulton and Watt, Engineers, Soho, Birmingham.

Presented by Mr. T. R. Guppy, Naples. 1878.

Note.—The principal dimensions of the "GREAT BRITAIN." Length, keel 289 ft., extreme 320 ft., breadth 51 ft., depth 31 ft. from keel to upper deck. Draught, loaded, 16 ft. The original engines by Boulton & Watt, had four inclined cylinders, each 88 ins. diameter. Stroke 6 ft. They drove a huge drum, which by chain gear drove a pulley on the screw shaft at 80 revolutions per minute. Steam pressure at boiler 15 lbs. to 20 lbs. per square inch. The boiler had 24 fires, worked fore and aft, and was 33 ft. square on plan. The "GREAT BRITAIN" was subsequently fitted by J. Penn

& Sons with a new set of engines on the oscillating cylinder system, spur wheel and pinion gearing. Cylinders, 82 ins. diameter, 72 ins. stroke.

For model of the engines of the "Great Britain," see page 195.

135A. WHOLE MODEL. Screw steamship "NOVELTY." Built 1839–40. Length 117 ft., breadth 24 ft. 6 ins., depth 14 ft. 6 ins. Engines direct acting. Two 14 in. cylinders, stroke 2 ft. 4 ins.

Lent by Mr. H. Wimshurst. 1878.

136. HALF BLOCK MODEL. Cape Mail steamship "EDINBURGH CASTLE." Messrs. Donald Currie & Co.'s line. Built of iron, 1872, by R. Napier & Sons, Glasgow. Length 335 ft., breadth 37 ft. 7 ins., depth of hold 28 ft. 2 ins. Tons 2,678. Engines of 300 nominal horse-power, by R. Napier & Sons.

Lent by Messrs. Donald Currie & Co., 3, Fenchurch Street, E.C. 1878.

137. WHOLE MODEL. Screw steamer "HAN KWANG." Chinese coasting trader. Built of iron, 1876, by Laird Brothers, Birkenhead. Length 230 ft., breadth 33 ft., depth 22 ft. 3 ins. Tons gross 1,233. Load draft 12 ft. 6 ins. Horse-power 800 indicated.

Lent by Messrs. Laird Brothers, Birkenhead. 1879.

138. WHOLE MODEL. Scale ¼ in. to 1 ft. The City Line steamship "CITY OF LIVERPOOL." Built 1881, by Charles Connell & Co. Length 400 ft., breadth 42 ft., depth of hold 30 ft.

Messrs. Charles Connell & Co., Scotstoun, Glasgow. 1881.

Note.—The ship's compound engines 650 nominal horse-power, have two cylinders, 50 and 96 ins. diameter, respectively. Stroke 5 ft. Steam pressure at boilers 80 lbs.

139. WHOLE MODEL. Scale ¼ in. to 1 ft. The Peninsular and Oriental Company's screw steamship "CLYDE." Steel built, 1881, by W. Denny & Brothers. Length 390 ft., breadth 42 ft., depth 34 ft.

Messrs. W. Denny & Brothers, Dumbarton. 1881.

Note.—The machinery of the "CLYDE" by W. Denny & Co. The engines are direct-acting surface condensing two cylinder, 58 ins. and 100 ins. diameter. Stroke 5 ft. 3 ins. Revolutions 60 per minute. Indicated horse-power 4,500. Four steel boilers, 13 ft. 10 ins. diameter, and 16 ft. long, with six fires in each; supply steam at 90 lbs. per sq. inch.

140. HALF BLOCK MODEL. Scale ¼ in. to 1 ft. The Beaver Line steamship "LAKE CHAMPLAIN." Dominion of Canada line. Built of iron, 1874, and engined by the lenders.

The London and Glasgow Shipbuilding Company, Glasgow. 1881.

Note.—The steamship "LAKE CHAMPLAIN" is of the following dimensions, 321 ft. long, 35 ft. broad, 26 ft. deep. Gross tons 2,210. Nominal horse-power 250. Speed 11 knots.

141. HALF BLOCK MODEL. Scale ¼ in. to 1 ft. The State Line steamship "STATE OF NEBRASKA." Glasgow to New York. Iron built, and engined 1880, by the lenders.

Lent by the London and Glasgow Shipbuilding Company, Glasgow. 1881.

Note.—The steamship "STATE OF NEBRASKA" is 385 ft. long, 43 ft. broad, and 34 ft. deep. Gross tons 4,100. Indicated horse-power 3,500.

142. HALF MODEL. The Royal Mail Company's steamship "GUADIANA." Built and engined 1874 by the exhibitors.

Lent by the London and Glasgow Shipbuilding Company, Glasgow. 1881.

Note.—The Royal Mail steamship "GUADIANA" is 330 ft. long, 36 ft. broad, 28 ft 6 ins. deep. Gross tons 2,504. Engines, nominal horse-power 300. Two cylinders, 46 and 82 ins. diameter, respectively. Stroke 45 ins. Boiler steam pressure 70 lbs. per square inch.

143. HALF BLOCK MODEL. The Orient Line screw steamship "ORIENT." Iron built. Messrs. John Elder & Co., Govan, Glasgow, 1879. Length 405 ft., extreme 460 ft., breadth 46 ft. 3 ins., depth, moulded, 36 ft. 10 ins. Tons gross 5,386. Nominal horse-power 1,000.

The Orient Steam Navigation Company, 13, Fenchurch Avenue, E.C. 1882.

Note.—The "ORIENT" carries coal for 40 days, full steaming. She has run from London to Melbourne, round the Cape of Good Hope, in 34½ days. She will carry 3,000 tons weight of cargo, 120 first, 130 second, and 300 to 600 third class passengers. Her crew is 150. Speed 15 knots per hour.

144. HALF BLOCK MODEL. The Orient Line Screw steamship "AUSTRAL." Steel built. Messrs. John Elder & Co., Glasgow, 1882. Designed by J. W. Shepherd, N.A. Length 455 ft., breadth 48 ft. 3 ins., depth, moulded, 57 ft.

Displacement, loaded line, 9,500 tons. Indicated horse-power 6,000.

The Orient Steam Navigation Company, 13, Fenchurch Avenue, E.C. 1882.

Note.—The steamship "AUSTRAL" is 10 ft. longer, 2 ft. wider, and 2 ins. deeper than the steamship "ORIENT." She is double bottomed, with 19 water-tight compartments, and has 13 water-tight bulkheads in her hull. The engines are three cylinder compound inverted; with one cylinder 62 ins. and two cylinders 86 ins. diameter. Stroke 5 ft. Separate engines supply water to condensers. Four steel boilers, 16 ft. diameter and 17 ft. long, with six fires in each, supply steam at 95 lbs. per sq. in. Speed of ship on trial 17·3 knots per hour. Actual indicated horse-power 7,114·36. Coal was consumed at the rate of 1·3 lbs. per hour per indicated horse-power. The ship is lighted at night by electric light.

See also steamship "Ormuz," No. 169.

145. WHOLE MODEL. The screw steamships "OREGON," "SARNIA," and "OTTAWA." Built of iron by Charles Connell & Co, Glasgow, 18—, for the Mississippi and Dominion (of Canada) Steamship Company, Liverpool.

Messrs. Flinn, Main, and Montgomery, Liverpool. 1882.

Note.—The model represents steamships, 360 ft. long, 40 ft. broad, and 32 ft. 6 ins. extreme depth. Gross tons 3,712. They are fitted with two-cylinder inverted compound surface condensing engines, having cylinders 49 and 87 ins. diameter. Stroke 4 ft. 6 ins. Indicated horse-power 2,400. Boiler steam pressure, 80 lbs. per square inch. The machinery constructed by Messrs. John and James Thomson, Engineers, Glasgow.

146. WHOLE MODEL, rigged. The Royal Cape Mail Steamship "MOOR." Built of steel, 1882, by Messrs. James and George Thomson, Clyde Bank, Glasgow. Length 365 ft., breadth 45 ft. 6 ins. depth 32 ft. 6 ins. Gross tons 4,000. Indicated horse-power 4,000. Speed 15½ knots per hour.

The Union Steamship Company, 11, Leadenhall Street, E.C. 1882.

Note.—The machinery of the steamship "MOOR" is by J. and G. Thomson, Clyde Bank. The engines are two-cylinder inverted compound condensing, with 51 and 90 in. diameter cylinders. Stroke 5 ft. Revolutions 69¾ per minute. Six boilers of steel supply steam at 90 lbs. per square inch.

147. WHOLE MODEL. Scale $\frac{1}{8}$-in. to 1 ft. The Anchor Line Company's screw steamship "CITY OF ROME." Built of steel and engined by the Barrow-in-Furness Shipbuilding Company, 1882. Length 560 ft. (extreme, 610 ft.), breadth 52 ft. 3 ins., depth 37 ft. Tons, B.M., 8,415 Indicated horse-power 10,000.

Lent by the Barrow-in-Furness Shipbuilding Company, Lancashire. 1882.

Note.—The "CITY OF ROME" is fitted with compound tandem inverted engines, having three sets of cylinders 43 and 86 ins. in diameter. Stroke 6 ft. They drive a three-crank steel shaft 25 ins. in diameter. The boilers of steel, eight in number, 19 ft. long, and 14 ft. diameter, supply steam at 90 lbs. per square inch.

148. WHOLE MODEL. Ocean-going screw steamship "VINDOBALA." Length 261 ft., breadth 34 ft. 3 ins., depth 21 ft. 8 ins. Tons, nett register, 1,134.

Lent by Messrs. Hepple & Co., Wapping Street, South Shields. 1882.

For another model lent by Hepple & Co., see page 34.

149. HALF BLOCK MODEL. The emigrant screw steamship "DORSET." Length 340 ft., breadth 39 ft., depth 26 ft. 4 ins. Tons gross 2,637. Horse-power 1,800 indicated. Built 1881 by the exhibitors for the Great Western Steam Shipping Company, Bristol.

Messrs. J. L. Thompson & Sons, North Sands Shipbuilding Yard, Sunderland. 1882.

150. HALF BLOCK MODEL, on a scale of $\frac{3}{16}$-in. to 1 ft. Proposed twin-screw Atlantic service steamship of 10,000 tons gross; and 20,000 indicated horse-power.

Lent by Messrs. Archibald McMillan & Co., Dockyard, Dumbarton. 1882.

Note.—The details of this vessel, designed for the Atlantic service, are as follows:—

Length between perpendiculars 600 ft., breadth, extreme, 70 ft., depth moulded 39 ft. Displacement at 26 ft. draft of water 19,835 tons. Freeboard amidships at 26 ft. draft 13 ft. 1 in. Dead weight of ship (sea trim) 12,500 tons.

The hull is divided into 44, and the double bottom and bilges into 22, watertight compartments. In the double bottom and bilges are 1,800 water-ballast compartments.

The vessel to be propelled by two screws, each 22 ft. diameter, and 35 ft. pitch. Speed of ship on 23 ft. draft, estimated at 20 knots per hour.

The screws driven by two distinct engines, each being a 4-cylinder inverted compound triple-expansion engine, having one cylinder of 44 ins., one cylinder of 66 ins., and two cylinders of 100 ins. diameter.

Stroke 72 ins. Revolutions 59 per minute. Twelve steel boilers with six furnaces each, supply steam to the engines at 125 lbs. per square inch.

Since this proposition appeared, the Inman line twin-screw steamships "CITY OF PARIS" and "CITY OF NEW YORK" for the Atlantic service, each vessel measuring 10,500 tons gross, and 20,000 indicated horse-power, have been engined and built of steel, 1888, by Messrs. J. and G. Thomson, Clyde Bank, Glasgow.

151. HALF BLOCK MODEL. Iron screw steamships "HAWARDEN CASTLE" and "NORHAM CASTLE." Built and engined, 1883, by John Elder & Co., Glasgow, for the Castle Mail Packets Company, London and Cape of Good Hope.

Length between perpendiculars 380 ft., breadth, moulded, 48 ft., depth, moulded, 32 ft. 10 ins. Tonnage, gross, 4,240. Indicated horse-power 4,100. Speed 14·7 knots.

Messrs. Donald Currie & Co., 3 and 4, Fenchurch Street, E.C. 1883.

See also model "Roslin Castle," No. 156.

152. WHOLE MODEL. The Union Royal Mail screw steamship "MEXICAN." Employed in the Cape of Good Hope, Natal, and East African service.

Lent by the Union Steamship Company, 11, Leadenhall Street, E.C. 1884.

Note.—The steamship "MEXICAN" was built, 1882, by James Laing, Deptford Yard, Sunderland. Length 392 ft., breadth 47 ft., depth 33 ft. 8 ins. Tonnage, gross, 4,669.

The engines, by G. Clark & Co., Sunderland, are compound inverted surface condensing. Cylinders, 50 and 94 ins. diameter. Stroke 54 ins. Indicated horse-power 3,700.

152*a*. HALF BLOCK MODEL. The Union Cape Mail screw steamship "TARTAR." Built by Aitken and Mansel, Whiteinch, Glasgow, 1883. Dimensions, 376 × 47 × 30 ft. Gross tons 4,359. Engines by J. and J. Thomson, Glasgow. Horse power 3,700 indicated.

Lent by the Union steamship Company, 11 Leadenhall Street, E.C. 1887.

Note.—The "TARTAR" has 30 water-tight compartments in her hull, and a double-bottom carrying 500 tons of water ballast. Her upper and main decks are of iron covered with

teak planking. In 1888 she was refitted by T. Richardson and Sons, Hartlepool, with new boilers and new engines on the triple expansion compound system, having three cranks and three inverted cylinders. Horse-power 4,750 indicated. She fulfils Admiralty requirements for Imperial Service and is lighted throughout by electric light.

153. WHOLE MODEL, on a scale of ¼ in. to 1 ft. H.M.'s telegraph cable-laying ship "MONARCH."

Lent by Mr. W. R. Culley, 15, Maryon Road, Old Charlton, Kent. 1885.

Note.—The "MONARCH" was built and engined, 1883, by D. J. Dunlop, Port Glasgow. She is constructed of iron, and is double-bottomed. Length between perpendiculars 240 ft., breadth, moulded, 33 ft., depth, moulded, 20 ft. Displacement at 15 ft. 3 ins. mean draught of water, 2,135 tons, at 16 ft. 2,090 tons.

Weight of ship and equipment 1,240 tons. The vessel has three cable tanks and two over-hung cable-drums, and is capable of carrying fuel and water-supply for six weeks.

Her engines are inverted cylinder compound, having cylinders 30 and 58 ins. diameter, with 4 ft. stroke. Indicated horse-power 1,040. Her boilers supply steam at 80 lbs. per square inch.

154. WHOLE MODEL, on a scale of ¼ in. to 1 ft. The Cunard Line steamships "UMBRIA" and "ETRURIA." Built and engined, 1884, by John Elder & Co., Glasgow.

The Cunard Steamship Company, Liverpool. 1885.

Note.—The dimensions of the screw steamships "UMBRIA" and "ETRURIA" are as follows:—Length 520 ft., breadth, moulded, 57 ft., depth 40 ft. Tonnage, gross, 8,000. Indicated horse power 13,500.

The screw steamships "UMBRIA" and "ETRURIA" were built in 1884 by John Elder & Co., Glasgow. Both steamships are constructed entirely of steel, and both are on Admiralty list as suitable for imperial service as armed cruisers. The screw steamships "UMBRIA" and "ETRURIA," sister vessels, are fitted with three-cylinder compound inverted engines, having one high pressure cylinder of 71 ins. diameter, and two low pressure cylinders of 105 ins. diameter each. Stroke 6 ft. Nine steel boilers supply steam at 110 lbs. per square inch pressure. These ships are lighted by electric lights, and are replete with every recent appliance and improvement.

155. WHOLE MODEL. Scale 1 in. to 4 ft. The White Star Royal Mail steamship "BRITANNIC." Built, 1874, by Messrs. Harland and Wolf, Belfast.

Messrs. Ismay, Imrie, & Co., Liverpool. 1885.

Note.—The dimensions of the steamship "BRITANNIC" are as follows:—Length over all 480 ft., breadth 50 ft., depth 35 ft. Tonnage 5,004. The boilers and engines by Maudslay, Sons, and Field, London, are 760 nominal horse-power, 5,090 indicated. Diameter of cylinders 48 and 83 inches. Stroke 5 feet. The engines are tandem cylinder inverted. A pair of cylinders drive each crank on main shaft. The trial speed of ship gave 16 knots per hour. The screw propeller was arranged with a lifting and lowering arrangement to meet the varying requirements of the ship's draught of water, or other contingencies.

The White Star Steamship Company have now building (1888) for their service two magnificent twin-screw steamships by Messrs. Harland and Wolff of Belfast. They are constructed throughout of steel, are fitted with water-tight compartments and full transverse and longitudinal bulkheads. In their construction many new features are adopted. The ships fulfil the Admiralty requirements for state service as armed cruisers. The collective engine power of each will exceed 20,000 horses, indicated; and their tonnage 10,000. Their speed is estimated to equal 20 knots per hour at sea.

156. WHOLE MODEL. Screw steamship "ROSLIN "CASTLE." Royal mail service to Cape Colony, Natal, and Mauritius.

The Castle Mail Packets Company (Donald Currie & Co.), 4, Fenchurch Street, E.C. 1886.

Note.—The "ROSLIN CASTLE" was built, 1883, by Barclay, Curle, & Co., Glasgow. Length 380 ft., breadth 48 ft. 2 ins., depth 32 ft. 8 ins. Tons, gross, 4,280. She is fitted with compound inverted direct-acting engines of 600 nominal horse-power, with cylinders 50 and 90 ins. diameter. Stroke 60 ins. Steam is supplied by three boilers 17¼ ft. × 14½ ft., with six furnaces each. Speed 13½ knots per hour.

157. WHOLE MODEL, on a scale of ¼ in. to 1 ft. Anchor Line screw steamship "BELGRAVIA."

Messrs. Henderson, Brothers, 47, Union Street, Glasgow. 1886.

Note.—The "BELGRAVIA" was built of iron, 1882, by D. and W. Henderson & Co., Partick, Glasgow, for the Anchor Line.

Length 400 ft., breadth 44 ft. 10 ins., depth 33 ft. Tons, gross, 4,977. The shell is flush plated, and fitted with outside doubling plates. Her engines, 3,260 indicated horse-power, are surface-condensing, having cylinders 57 and 103 ins. diameter. Stroke 48 ins. Steam is supplied at 70 lbs. pressure by six single-ended iron boilers, having 18 furnaces, and two steel boilers having eight furnaces.

Consumption of coal 50 tons per diem. Speed, loaded, 13 knots per hour.

158. WHOLE MODEL. Royal Mail screw steamships "KAIKOURA" and "RIMUTAKA," London to New Zealand service.

Lent by the New Zealand Shipping Company, 138, Leadenhall Street, E.C. 1886.

Note.—The "KAIKOURA" and "RIMUTAKA" were built of steel, and engined, 1884, by John Elder & Co., Glasgow, for the New Zealand Shipping Co. Length, over all, 451 ft., breadth 45 ft. 9 ins., depth, moulded, 33 ft. 4 ins. Tons, gross, 4,475. Indicated horse-power 4,000. Speed 15 knots. Three steel double-ended boilers supply steam at 110 lbs. per sq. in. to engines on the two-cylinder inverted compound principle. The ships are lighted by electricity.

159. WHOLE MODEL. The Peninsular and Oriental Company's screw steamship "MASSILIA."

The Peninsular and Oriental Steam Navigation Company, 122 Leadenhall, E.C. 1886.

Note.—The "MASSILIA" was built, 1883, by Caird & Co., Greenock. Length 420 ft., beam 45 ft., depth 36 ft. Tons, gross, 4,911. Indicated horse-power 5,000. The Peninsular and Oriental steamers "MASSILIA" and "ROSETTA," were chartered, fitted up, and employed by H.M.'s Government as armed cruisers for colonial defence, 1885–6.

For a model of the older "Massilia" see No. 68.

160. WHOLE MODEL, rigged. The screw steamship "ORINOCO." Employed in the West India Mail Service.

Lent by the Royal Mail Steam Packet Company, 18, Moorgate Street, E.C. 1886.

Note.—The "ORINOCO," was built and engined in 1886 by Caird & Co., Greenock. Length 390 ft., breadth 45 ft., depth 34 ft. 10½ ins. Indicated horse-power 5,000. Tons, gross, 4,627. Speed, on trial, 16 knots per hour. Eight steel boilers supply steam at 150 lbs. per square in. to the three-cylinder inverted triple expansion compound engines, having cylinders of 42, 62, and 96 inches diameter, with a stroke of 66 ins. The ship is lighted by electricity, and fitted out in the most recently approved fashion.

161. WHOLE MODEL. Iron screw steamship "CITTA DI MILANO." Built 18 , for laying and repairing submarine telegraph cables.

Lent by Messrs. R. Thompson and Sons, Southwick Yard, Sunderland. 1887.

Note.—The length of the steamship "CITTA DI MILANO," is 240·0 ft., breadth 32·2 ft., depth 23·75 ft. Gross tonnage 1,246. Indicated horse-power 1,100. Classed 100 A 1 at Lloyds. She was built for the service of the

Italian Government, and is employed in the Mediterranean in telegraph submarine cable maintenance.

162. WHOLE MODEL. Mail and passenger screw steamers "VILLE DE PARA" and "VILLE DE CEARA." Built by the lenders, 1882.

Lent by Messrs. Schlesinger, Davis, and Co., Wallsend, Newcastle-on-Tyne. 1887.

Note.—The length of each vessel is, over all, 300 ft., breadth, moulded, 37 ft. depth, moulded, 27 ft. 9 in., gross tonnage 2,355. Engines 1,400 indicated horse-power.

163. WHOLE MODEL, rigged. Steel-built screw steamships "KNIGHT OF ST. JOHN," and others. Built and engined at Jarrow.

Lent by Palmer's Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne. 1887.

Note.—Three other vessels have been built on the same lines as the "KNIGHT OF ST. JOHN," viz., steamship "KNIGHT ERRANT," steamship "WORSLEY HALL," and steamship "METHLEY HALL." Length 330 ft., breadth 43 ft. 3 ins., depth 29 ft., displacement on 25 ft. draught of water 7,260 tons, dead weight 4,800 tons. The engines are triple expansion, having cylinders 27, 44, and 71 ins. diameter; stroke 48 ins., indicated horse-power 1,600, steam pressure in boilers 150 lbs. per square inch. Average speed at sea, loaded, 10½ knots.

164. WHOLE MODEL, rigged. Inman Line screw steamship "CITY OF CHICAGO." Built, 1883, by C. Connell and Co., Glasgow.

Lent by the Inman and International Steamship Company (Richardson, Spence, & Co.), Tower Buildings, Water Street, Liverpool. 1887.

Note.—The steamship "CITY OF CHICAGO" is 430 ft. long, 45 ft. wide, and 33 ft. 6 ins. deep. Gross tonnage 5,201. The engines, by J. and J. Thompson, Glasgow, are 3-cylinder compound, having one high-pressure cylinder 56 ins. diameter, and two low-pressure cylinders 80 ins. diameter. Stroke 5 ft. Boiler steam pressure 90 lbs. per square inch. Horse-power, nominal, 900, indicated 5,000.

165. WHOLE MODEL, rigged. Screw steamers "WARRINGTON" and "NORTHENDEN." For service between Grimsby and Hamburg. Built 1886.

Messrs. Swan & Hunter, Wallsend, Newcastle-on-Tyne. 1887.

Note.—The "NORTHENDEN" was built, 1886, for the Manchester, Sheffield, and Lincolnshire Railway Company's North Sea carrying service. Length 230 ft., breadth 30 ft.

depth 15 ft., tonnage 850. Engines, triple-expansion, surface condensing. Cylinders 22 ins., 35 ins., and 57 ins. diameter. Stroke 42 inches. Indicated horse-power 1,150. Steam is supplied by two steel boilers, at 150 lbs. per square inch pressure. Speed of ship 12½ knots per hour.

166. WHOLE MODEL, on a scale of ¼ in. to 1 ft. Design. Steel twin-screw Atlantic liner.

Messrs. Swan & Hunter, Wallsend, Newcastle on-Tyne. 1887.

Note.—The tonnage of this vessel, designed for the Atlantic mail and passenger service, is 7,200 gross tons. Her length 460 ft., breadth 63 ft., depth 36 ft. She is to be propelled by twin screws driven by triple-expansion engines of 18,000 indicated horse-power. The double set of engines comprise two high-pressure cylinders of 48 ins. diameter, two intermediate cylinders of 78 ins., and four low-pressure cylinders of 88 ins. diameter. Stroke 72 ins. Twelve double-ended steel boilers, with 72 furnaces, supply steam at a pressure of 160 lbs. per square in. Estimated speed 21 knots or 24¼ miles per hour.

167. WHOLE MODEL, rigged. The Anchor Line steamship "CITY OF ROME."

Messrs. Henderson Brothers, Glasgow. 1887.

Note.—The "CITY OF ROME" was built by the Barrow-in-Furness Shipbuilding and Engineering Company in 1882. She is more fully described on page 54.

168. HALF MODEL. Scale ¼ in. to 1 ft. Screw steamer "THISTLE." Built of iron at South Shields, 1879.

Lent by Mr. J. T. Eltringham, Stone Quay Works, South Shields. 1887.

Note.—The "THISTLE" is 166 ft. long, 24 ft. wide, and 13 ft. deep. Her registered tonnage is 323 tons. Compound surface-condensing engines of 60 horse-power nominal, constructed by Pattison & Atkinson, Newcastle-on-Tyne, drive the screw propeller. Steam at a working pressure of 65 lbs. per square inch, is supplied by a multitubular boiler. The crew consists of about 13 hands.

For other objects lent by Mr. J. T. Eltringham, see pages 77, 89, 169.

169. HALF MODEL. The Orient Royal Mail screw steamship "ORMUZ."

Lent by the Orient Steam Navigation Company, 13, Fenchurch Avenue, E.C. 1887.

Note.—The steamship "ORMUZ," constructed of steel. was built and engined, 1887, by John Elder & Co., Glasgow.

Length between perpendiculars 465 ft., breadth 52 ft., depth, moulded, 37 ft. Tonnage 6,500. Horse-power indicated 7,500, speed 18 knots per hour. The ship's displacement at 26 ft. draught of water is 10,000 tons. Her engines are on the compound 3-cylinder 3-crank system. Diameter of cylinders 46, 73, and 112 inches. Stroke 6 ft. Seven steel boilers supply steam at 150 lbs. per square inch pressure. The "ORMUZ" has performed some very remarkable passages since she began regular service, averaging 15½ to 15¾ knots per hour for days together outward and homeward. The "ORMUZ" is fitted out with every modern appliance for efficiency and comfort, and is lighted throughout with electric lights.

See also screw steamships "Orient" and "Austral," Nos. 143, 144.

170. WHOLE BLOCK MODEL. Screw steam ariso, "DONNA MARIA ANNA." Tons 400. Horse-power, nominal, 80. Built 1859 for the Portuguese Government by John Scott, Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

171. WHOLE BLOCK MODEL. Screw steamships "ADELAIDE" and "VICTORIA." Tons 1852. Horse-power, nominal, 450. Built 1852 for the Australian Royal Mail Steam Navigation Company, by John Scott Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

Note.—The "VICTORIA" gained the prize of 500*l.* offered about the year 1852, by the Australian colonies, for the fastest voyage to Australia.

172. WHOLE BLOCK MODEL. Screw steam clipper "ANNETTE." Tons 845. Horse-power, nominal, 100. Built of iron, 1861, for A. Rimington, Esq., by John Scott Russell & Co., Millwall.

Transferred from the Patent Museum. 1885.

Note.—The "ANNETTE" was built on the longitudinal system, and was classed A1 12 years at Lloyds. She was full rigged, and had a lifting screw.

NOTE ON SCREW STEAMSHIPS CARRYING CARGOES OF PETROLEUM OIL IN BULK.

Since the rise of the use of petroleum and mineral oils for the present innumerable purposes for which these oils are commercially valuable, it has been found advantageous

to devise special steamships constructed with huge tanks in their holds to carry the oils in bulk, and not, as heretofore, in casks or barrels.

The oil wells of America and Southern Russia absorb the principal petroleum industries extant, and the transport of the oil from these countries occupies a considerable amount of ship tonnage.

The first steamship built for the petroleum oil trade carrying her cargo in bulk, was turned out in 1886 by Messrs. Armstrong, Mitchell & Co., Low Walker, Newcastle. The ship measured 300 feet long, and had a tonnage of 3,000 tons burden. Her engines and boilers were fitted by the Wallsend Shipway and Engineering Company, of Newcastle. The following names of steamships built for oil carrying, will perhaps give a clue to further information about these special vessels:—"GLUCK-AUF," built at Newcastle, 1886; the "SVIET," built at Motala, Sweden, 1885; another built at Newcastle, 1887, with Swan's oil tanks and system of ventilating them. In the fall of the year 1887, the following vessels for petroleum oil carrying in bulk were completed:—The steamship "POLLUX," at Dundee; the steamship "VILLE DE CALAIS," at Newcastle; the steamship "OLGA," at Birkenhead; the steamship "MINISTER MAYBACK," at Newcastle. The steamship "CAUCASE," built entirely of steel, and carrying 2,400 tons of oil, was completed at Newcastle in 1888; and at the same place in the same year the "KASBEK," screw steamship carrying 4,000 tons of oil in seven large tanks.

CLASS I.

Mercantile Marine.—Sailing Ships.

NOTE ON SAILING SHIPS.

In the collection of ship models will be found a small but representative series of models of sailing ships pure and simple. Attention may be given to the old vessels (two brigs) "ANTELOPE," built 1757, and the "BROTHERLY LOVE," built 1764. From the time of these vessels, improvements in sailing ships of all classes were rapidly conceived and carried out. Perhaps a marked epoch in the reign of sailing ships was the period 1839 to 1869, when the celebrated vessels known as "Aberdeen Clippers" were turned out. The lines of these vessels were remarkable, and their speed great. America and Britain both produced in rivalry this class of swift sailing ship. The "SCOTTISH MAID," "NONSUCH,"

"ARIEL," "TAEPING," "FIERY CROSS," and others, afford examples. Schooners, brigs, barques, and ships were built.

The recent four-masted sailing vessels of iron or of steel, such as the "WATERLOO," and "SIMLA," built 1878; "BAY OF CADIZ," built of steel, 1879; "GARFIELD," 1881; "VANDUARA," 1882; "FINGAL," 1883; "PALGRAVE," 1884; "BRIDSTON HILL," 1886; "DRUMCLIFFE," 1887; have been represented from time to time in the collection. The "DORIS,' a sailing barque, built at Dundee in 1887, may be here mentioned, on account of her construction on the recent composite principle of iron and steel combined.

SAILING SHIPS.

174. HALF MODEL. The iron sailing ship "VICTORY," Tons 1,198. Built 1863. Designed and built by Messrs. Laurence, Hill, & Co. for Messrs. Potter, Wilson, & Co., Glasgow.

Presented by Messrs. Laurence, Hill & Co., Glasgow. 1865.

Note.—The "VICTORY" on her first voyage in 1863 ran from the Clyde to Port Chalmers, New Zealand, in 72 days.

From anchorage to anchorage 77 days, under Mr. W. Gibbon, Master.

175. WHOLE MODEL. The iron sailing ship "DURHAM." Designed and built by Messrs. Oswald & Co. for Messrs. Temperley, Carter, & Co., London.

Lent by Messrs. Oswald & Co., Sunderland. 1867.

Note.—The principal dimensions of the sailing ship "DURHAM" are:—Length, over all, 209 ft. 6 ins.; breadth 34 ft. 9 ins.; depth 20 ft. 9 ins.; tonnage B.M., 1,131; register, 998; draft, light, 8 ft. 2½ ins.; laden, 18ft. 4½ ins.; displacement at load line, 1,378 tons.

176. HALF BLOCK MODEL. Scale ¼ in. to 1 ft. The clipper sailing ship "FIERY CROSS." Built 1855. Length 173 ft., breadth 31 ft. 6 ins., depth 18 ft. 9 ins. Tonnage, o.m. 810. The ship was built by Messrs. Rennie and Rankie, Liverpool, from designs by Mr. Rennie.

Lent by Mr. J. Campbell. 1869.

177. WHOLE MODEL. Scale ¼ in. to 1 ft. The clipper merchant sailing ship "FIERY CROSS." Built, 1861, for the China tea trade, by Chaloner, Hart, & Co., Liverpool. Designed by Mr. Rennie. Dimensions are as follows:—Extreme length 185 ft., extreme breadth 31 ft. 3 ins., depth 19 ft. 6 ins. Tonnage, o.m. 363, register 703. Displacement 1,615·84 tons.

Lent by Mr. J. Campbell. 1869.

177A. HALF BLOCK MODEL. Scale ½ in. to 1 ft. A British merchant clipper sailing ship. Length 170 ft., beam 28 ft.

Lent by Mr. J. Campbell. 1869.

178. WHOLE MODEL. Scale ½ in. to 1 ft. The merchant sailing ship "CYGNET," on launching ways. The port side built, starboard side showing ship's framing and disposition of timbers.

Lent by Mr. A. T. Lowe. 1870.

179. WHOLE MODEL, rigged complete. Dutch galiot of the period 1774–1778. The model bears these dates. It is richly carved throughout, specially at the bow and stern, hatchways, leeboards, &c. Length of model 3 ft. 2 ins., beam 12 ins.

Purchased. 1871.

180. WHOLE MODEL, rigged. The merchant sailing vessel "ANTELOPE." Built in the year 1757.

Lent by Mr. James J. Young, West Docks, South Shields. 1876.

181. WHOLE MODEL, rigged. The merchant sailing vessel "BROTHERLY LOVE." Built in the year 1764, and is said to be still employed, 1876. The mark on the side represents damage from a collision with a steamer some years ago.

Lent by Mr. James Young, West Docks, South Shields. 1876.

182. HALF BLOCK MODEL of the ships "JAMES NICHOL FLEMING," and "OTAGO." Built on the composite principle in 1869.

Lent by R. Duncan & Co., Port Glasgow. 1876.

Note.—The model shows the upper deck plan of the ships, their diagonal iron bracing, and other details of construction. Their dimensions are:—Length 205 ft., beam 34 ft. 6 ins., depth 20 ft. 6 ins., tonnage 1,000 gross.

183. HALF BLOCK MODEL of the sailing ship "JAPANESE."

Lent by Mr. T. Royden, Liverpool. 1876.

184. WHOLE MODEL of an iron sailing ship about 1,800 tons register. Designed by Charles H. Jordan.

Mr. C. H. Jordan Greenwich. 1877.

185. WHOLE MODEL. Iron sailing ship designed by Mr. Gilbert Rowe, 31, Guildford Road, Greenwich.

Lent. 1877.

Note.—The model represents an iron sailing ship above 1,200 tons register. She is a clipper ship, with full poop and topgallant forecastle, with extensive accommodation for first-class passengers, together with a large carrying capacity. The starboard side of the model shows horizontal longitudinal sections, and the port side shows vertical longitudinal sections. Her principal dimensions are :—Length, over all, 220 ft. 6 ins.; length of keel and fore rake 212 ft.; breadth, extreme, 37 ft.; depth of hold 22 ft. 8 ins.; load draught 19 ft. 3 ins. Tonnage 1,297 $\frac{97}{100}$ tons. Displacement at load line 2,599 $\frac{31}{50}$ tons.

186. WHOLE MODEL. Trading ship "ARUNDEL CASTLE." Three masted sailing ship. London and the Cape of Good Hope.

Lent by Messrs. Donald Currie & Co., 3, Fenchurch Street, E.C. 1878.

187. WHOLE MODEL. The "CLEOPATRA," ship; used for conveying the obelisk, Cleopatra's Needle, from Alexandria to London, 1877–78. Iron. Built 1877. John Dixon and Benjamin Baker, engineers. Length 93 ft., diameter 15 ft., draught of water 9 ft., metacentric height 10·5 feet.

Presented by Mr. John Dixon, C.E., Lawrence Pountney Hill. E.C. 1879.

Note.—This model is on a scale of $\frac{1}{2}$ in. to 1 ft. The actual ship is now broken up. She was towed to England from Alexandria, and was fitted with spar deck and small cabin amidships, and carried a single mast rigged with gaff and foresail. The "CLEOPATRA" was built by the Millwall Ironworks Co., London.

188. WHOLE MODEL, rigged. The four-masted iron sailing ship "WATERLOO." Built 1878 by C. Connell & Co., Scotstoun, Glasgow. Length 272 ft., breadth 40 ft. 3 ins., depth 24 ft. 3 ins. Gross tons 1,976. Scale of model $\frac{1}{4}$ in. to 1 ft.

Messrs. Charles Connell & Co. Scotstoun, Glasgow. 1881.

Note.—The lower and topmasts of the ship "WATERLOO" are of iron in one length. Topgallant and royal masts are of wood. The ship is square rigged on all four masts.

189. HALF BLOCK MODEL. The iron sailing ships "LAMMERMOOR," 1874; "CEDRIC THE SAXON," 1875.

Built by John Reid & Co. Length 249 ft. 6 ins., breadth 40 ft., depth 23 ft. 8½ ins. Gross tons 1,704. Scale of model ¼ in. to 1 ft.

Lent by Messrs. John Reid & Co., Port Glasgow. 1881.

190. HALF BLOCK MODEL. Four-masted iron sailing ships, "COUNTY OF SELKIRK," "COUNTY OF HADDINGTON," "COUNTY OF ABERDEEN." Built 1878 by Barclay, Curle, & Co. Length 281 ft., breadth 40 ft. 6 ins., depth 24 ft. Tons, gross, 1,942.

Lent by Messrs. Barclay, Curle, & Co., Whiteinch, Glasgow. 1881.

191. HALF BLOCK MODEL. The four-masted iron built sailing ship "PALGRAVE." Length between perpendiculars 309 ft. 6 ins., breadth 49 ft., depth of hold 25 ft. 8 ins. Built 1884 by exhibitors. Tonnage $3{,}111\frac{60}{100}$ net register.

Lent by Messrs. Wm. Hamilton & Co., Newark Shipbuilding Yard, Port Glasgow. 1884.

Note.—The masts and lower yards of the "PALGRAVE" were of steel. She was fitted with steam donkey boiler to supply steam to the driving engines of the cranes, winches, windlass, pumps, and such like steam gear aboard ship. The "PALGRAVE" was said to be the largest sailing ship of her date.

192. WHOLE MODEL, on a scale of $\frac{3}{16}$ in. to 1 ft. The sailing ship "SOBRAON." A passenger and cargo vessel running between England, Australia, and New Zealand.

Lent by Capt. J. A. Elmslie. 1884.

Note.—The "SOBRAON," a full rigged ship, owned by Messrs. Devitt and Moore, London, was built on the composite system at Aberdeen in 1866. Her dimensions are:—Length over all $272\frac{1}{10}$ ft., breadth, extreme, $40\frac{3}{10}$ ft., depth of hold 20 ft., tons register 2,131½. The "SOBRAON" continues a favoured passenger ship, having been overhauled and re-fitted out recently on present day lines.

193. WHOLE MODEL, rigged. Iron built three-masted sailing ship "BHOTAN." Built 18 ? .

Lent by Messrs. R. Thompson and Sons, Southwick Yard, Sunderland. 1887.

Note.—The length of the "BHOTAN" is 214·7 ft., breadth 33·9 ft., depth 20·5 ft. Gross tonnage 1,137. Classed 100 A.1. at Lloyd's. The model shows the ship's hull plating, her upper-deck plan and arrangement, and the complete rig (without sails) of the ship.

194. SERIES OF NINE HALF BLOCK MODELS. Vessels built by Oswald, Mordaunt, & Co. Southampton.

a. Sailing ships "SCOTTISH HILLS," and "SCOTTISH DALES." Length 277 ft. 7 ins., breadth 40 ft. 3 ins., depth of hold 24 ft. Register tonnage 2,058.

b. Screw steamer "No. 200." Length between perpendiculars 382 ft., breadth, extreme, 44 ft. 3 ins., depth of hold 33 ft. 3 ins. Gross tonnage about 4,700.

c. Iron sailing ship. Length, extreme, 320 ft. 8 ins., breadth 44 ft. 3 ins., depth of hold 24 ft. 9 ins. Gross tons, 2,299.

d. Iron sailing ship. Length, extreme, 250 ft., breadth 38 ft. 3 ins., depth of hold 24 ft. Gross tonnage 1,803.

e. Sailing ship "COUNTY OF CLARE." Length, register, 335 ft. 6 ins., breadth 38 ft. 3 ins., depth of hold 22 ft. 9½ ins. Nett registered tonnage 1,497·73. Classed 100 A.1. at Lloyd's Registry.

f. Sailing ship "ALLERTON." Length, extreme, 287 ft., breadth 40 ft., depth of hold 24 ft. 4½ ins. Gross tonnage 2,080.

g. Screw steamship "SOLENT." Length, extreme, 336 ft. 6 ins., breadth, extreme, 34 ft. 9 ins., depth of hold 24 ft. Gross tonnage 1,908.

h. Screw steamship "CALEDONIA." Length, extreme, 281 ft. 6 ins., breadth 38 ft., depth of hold 18 ft. 3 ins. Gross tonnage 1,994. Indicated horse-power 770.

i. Model. Stern of twin-tailed, twin-screw, and twin-rudder vessel, of high speed. Designed by Mr. T. R. Oswald.

Messrs. Oswald, Mordaunt, & Co., Southampton.
1885.

195. HALF BLOCK MODEL. Schooner "SAINT." Built of wood, 1870, at Drogheda. Length 87 ft. 2 ins., mean breadth 21 ft. 3 ins., depth of hold 10 ft. 7 ins. Gross register tonnage 118·12. Carrying capacity 204 tons.

Lent by Messrs. Thomas Grendon & Co., Drogheda.
1888.

Note.—The "SAINT" has wooden masts. Her dimensions are Custom House dimensions.

196. HALF BLOCK MODEL. Three-masted schooner "JAMES DUCKETT." Built of iron, 1865, at Drogheda. Length, over all, 120 ft. 4 ins., breadth, moulded, 23 ft. 2 ins., depth 12 ft. 9 ins. Register tonnage 232.

Lent by Messrs. Thomas Grendon & Co., Drogheda. 1888.

Note.—The "JAMES DUCKETT" has wooden masts.

For other models lent by Thomas Grendon & Co., see pages 82, 268.

CLASS I.

Models of Home Vessels.—Fishing and Pilot Boats.—Sailing and Steam Barges.—Hoys and Coasting Vessels.

198. WHOLE MODEL, rigged. Thames sailing barge. Built 1855. Length 70 ft., breadth 16 ft., depth 6 ft.

Lent by Searle & Sons, Lambeth. 1865.

199. HALF BLOCK MODEL. Whitby five-man fishing boat. Length 57 ft., breadth 17 ft., depth 8 ft. 4 ins. Registered tonnage 45 tons.

Lent by Mr. T. Turnbull. 1869.

200. HALF BLOCK MODEL. "COBLE" of the Yorkshire coast. Each five-man fishing boat carries two cobles. The flat after end allows them to be easily beached. When under sail a rudder projecting 4 ft. below the stern is used.

Lent by Mr. T. Turnbull. 1869.

201. HALF BLOCK MODEL. Fishing "MULE" of the Yorkshire coast. Coble form forward, yawl form aft. Length 33 ft. 9 ins., breadth 10 ft., depth 4 ft. 9 ins. Scale 1 in. to 1 ft.

Lent by Mr. T. Turnbull, Whitby. 1871

202. HALF MODEL. The "MARY TAYLOR," New York pilot boat. Built in New York by George Steers, an Englishman, about 1850.

He afterwards built the celebrated "AMERICA" yacht. He told the exhibitor in New York, in September 1854, that he considered the "MARY TAYLOR" the faster vessel of the two, particularly in rough water.

Lent by Mr. Henry Liggins, 3, Ladbroke Square, Bayswater. 1876.

203. MODEL of a Shields coble.

Lent by Mr. James Young, West Docks, South Shields. 1876.

For other models lent by Mr. Young, see pages 64, 95, 150, 218.

204. WHOLE MODEL. Yarmouth trawling smack rigged. Without the trawl net.

Lent by Mr. John Bracey, Yarmouth. 1876.

205. HALF BLOCK MODEL. Sea-going fishing smack. Designed by T. V. Trew, Barking.

Lent. 1877.

Note.—The model represents a smack of the following dimensions: length, on deck, extreme 67 ft., breadth 19 ft., depth 9 ft. 6 ins., draught of water 9 ft.

206. HALF BLOCK MODEL. Sea-going fishing smack. Designed and built by T. V. Trew, Barking.

Lent. 1877.

Note.—This model represents a fishing smack of the following dimensions: length on deck 63 ft., breadth extreme 18 ft. 6 ins., depth 11 ft. 3 ins., draught of water 9 ft. 6 ins.

207. WHOLE MODEL. Thames lighter or barge, 1850. For carrying grain, coal, and other merchandize. Scale of model ½ in. to 1 ft.

Presented by Messrs. Searle & Sons, Lambeth, 1851. 1877.

Note.—This model of a Thames lighter is properly and correctly built. The inside is left partly unplanked to show the timbers. The outside is planked and finished. The plan view shows the hold, flooring, bow and stern fittings, and other detail.

208. WHOLE MODEL. Sea-going sailing barge. A topsail barge, to carry 85 tons on a 5 ft. 6 ins. draught of water. Designed by W. J. Talbot, Chiswick.

Mr. W. J. Talbot, Chiswick. 1877.

209. WHOLE MODEL. Fishing boat. Scale ½ in. to 1 ft. The steam fishing trawler "SCOTSMAN." 35 nominal horse-power. Rigged model.

Mr. William Jarvis, Anstruther, N.B. 1882.

210. WHOLE MODEL. Fishing boat, on a scale of ½ in. to 1 ft. The steam fishing boat "EDINA." 20 nominal

horse-power. 65 ft. boat. Steam speed 9½ knots per hour. Model is rigged.

Mr. William Jarvis, Anstruther, N.B. 1882.

Note.—The "EDINA" is fitted up for herring, line, and trawl fishing.

211. WHOLE MODEL. Fishing boat. Scale ½ in. to 1 ft. Line and net steam fishing boat "ROB ROY." Wooden built. Rigged model.

Lent by Messrs. A. G. Gifford & Co., Ship and Boat Builders, Leith. 1882.

212. WHOLE MODEL. Fishing boat. Scale ½ in. to 1 ft. Steam trawler "HAWK." Rigged model and fitted.

Lent by Messrs. A. G. Gifford & Co., Ship and Boat Builders, Leith. 1882.

213. WHOLE MODEL of a North Sea trawler, rigged, planned sails, and fitted complete. Fishing boat. Scale about 1 in. to 1 ft.

Lent by Mr. Edward Jex, 27, St. Mary-at-Hill, E.C. 1882.

Note.—The model represents an eight or ten man North Sea trawler, hailing from Lowestoft. She is fitted with all necessary gear for line and net fishing, and is ketch rigged.

214. FOUR HALF BLOCK MODELS, mounted. Barges. Sailing barges—

Top-sail barge.
Ketch or schooner-rigged barge.
86 ft. sailing barge, to carry 150 tons.
84 ft. sailing barge, to carry 150 tons.

Messrs. Surridge & Sons, Ship and Barge Builders, Millwall, E. 1882.

215. WHOLE MODEL, rigged. Fishing boat. Scale ¾ in. to 1 ft. Well vessel. Built 1883, at Rye, for the North Sea and Iceland cod fisheries. J. C. Hoad, Rye, Sussex, Builder (G. and J. Smith).

Purchased. 1883.

Note.—This model is constructed to show on the one side, the planking, fastening, and perforations for the free ingress and egress of the water, on the other side, the level lines and the interior of the wells. It represents a vessel of the following dimensions, length, between perpendiculars, $77\frac{3}{10}$ ft., breadth, extreme, $20\frac{3}{10}$ ft., depth, moulded, $12\frac{2}{10}$ ft. Registered 88 tons. A suit of sails is also exhibited.

216. HALF BLOCK MODEL. Fishing boat. Trawling ketch for the South Coast fisheries. Built at Rye, Sussex, by J. C. Hoad; J. and G. Smith, successors.

Purchased. 1884.

217. WHOLE MODEL, rigged. Fishing boat. Scale ¾ in. to 1 ft. The trawl fishing boat "CITY OF LONDON," of Hull. Built at Rye, Sussex, 1883.

Mr. J. C. Hoad (G. and J. Smith) Rye, Sussex. 1883.

Note.—The "CITY OF LONDON" is a ketch-rigged vessel carrying a crew of five hands. Length of keel 66 ft., breadth, extreme, 20 ft., depth in hold 10 ft. Tons register 71.

From April and during the Summer her fishing ground is on the Jutland Coast, Denmark, in the Winter, the Dogger Bank, Great Fisher Bank, Well Bank, and the Silver Pits.

218. WHOLE MODEL, cutter-rigged. Fishing boat. Scale 1½ ins. to 1 ft. Oyster dredging boat "SECRET." Built, 1856, at Wivenhoe, Essex.

Lent by Mr. F. Wiseman, Paglesham, Rochford, Essex. 1883.

Note.—The "SECRET" is a vessel of the following dimensions:—Length over all 33 ft., keel and fore rake 27 ft., beam 10 ft., depth (deck to keelson) 4 ft. 6 ins. Tonnage 11 tons, B.M. Draught, forward 3 ft. 6 ins., aft 5 ft. 9 ins. Recently she has been lengthened 3 ft. at the bow, with a view of improving her speed. Her crew consists of three hands. She is engaged in oyster dredging at the mouth of the Thames.

219. MODEL. Fishing boat on a scale of 1 in. to 1 ft. of a Shetland "SIXERN," "SIXAREEN," or six-oared yawl. (Old Norse *Sexoeringr.*)

Presented by J. R. Tudor, Esq., St. Leonards-on-Sea. 1883.

Note.—The boats represented by the model are built of Norway fir, and fastened with iron. Length on keel 20 ft., length over all 29 ft., beam amidships 8 ft., depth at stem head 5 ft., depth amidships 3 ft. 3 ins., depth at stern posts 4 ft. 9 ins. Oars (ars) 16 ft. long, pulled with one thole-pin called a "kabe," and a grummet called a "humlaband." Mast 22 ft., yard 18 ft., hoist of sail 18 ft. 6 ins. Total cost, all found, except nets and lines, 26*l.*

Till within the last 40 years or so, all the larger Shetland boats were imported direct from Norway in boards ready for putting together. At that time the boats rarely, if ever, exceeded 18 ft. on keel, and had a somewhat flatter floored

midship section. Even at the present day, most, if not all, of the names of the different portions of a sixern, and of the articles of her equipment, and of the terms used in her navigation and in connexion with fishing, are, at any rate in the outlying parts of Shetland, of Norse origin.

220. MODEL. Fishing boat on a scale of about 1 in. to 1 ft. of a Fair Isle (Shetland) skiff.

Presented by W. Lawrence, Esq., Fair Isle, Shetland. 1883.

Note.—The typical Fair Isle skiff is built of fir, and iron fastened. Length on keel 15 ft. 6 ins., length over all 22 ft., beam, extreme, 5 ft. 8 ins., depth at stemhead 3 ft. 6 ins., depth at stern post 3 ft. 3 ins. Mast (stepped nearly amidships) 14 ft. 6 ins., yard 11 ft., hoist of sail 14 ft. Three pairs of oars, each 10 ft. 2 ins. long, and are pulled, as in sixern, with "kabe" and "humlaband." Total cost, all found except fishing lines, 6*l.* 10*s.* The crew consists of three men.

In the last century similar boats seem to have been in use all over Shetland, but at the present day they are confined to Fair Isle.

221. MODEL. Fishing boat on a scale of 1 in. to 1 ft. of a Westray and North Isles yawl.

Presented by J. Barnett, Esq., Kirkwall, the Orkneys. 1883.

Note.—These yawls are built of oak and white Norwegian pine, and fastened with galvanized iron. Length on keel 14 ft., length over all 19 ft. 3 ins., beam extreme 7 ft. 6 ins., depth at stem head 4 ft. 7½ ins., depth at lowest point of gunwale 3 ft. 6½ ins., depth at stern post 4 ft. 4½ ins. Two pairs oars, one pair 14 ft., the other 12 ft. in length. Two masts each 16 ft., foremast stepped 2 ft. 4 ins from stem, mainmast stepped 9 ft. from stem. Bowsprit outboard 5 ft. The sails comprise, jib, lateen foresail, and lateen boom-mainsail. Jib hoist 13 ft., foot 6 ft. 6 ins. Foresail-yard 9 ft., hoist 12 ft., foot 10 ft. Mainsail-yard 8 ft. 6 ins., hoist 12 ft., foot 10 ft., boom 11 ft. Cost, equipped for sea, 15*l.* These yawls are now superseded by the "Firthy" boats in common use on the east coast of Scotland.

222. MODEL. Fishing boat, on a scale of 1 in. to 1 ft., of a Färoese "eight-man boat" equipped for the grind or chase of the Grindehval or Grindefish (*Delphinus deductor*, of Scoresby), and the Ca'in or Bottle-nosed Whale of Shetland and the Orkneys.

Presented by J. R. Tudor, Esq., St. Leonards-on-Sea. 1883.

Note.—These eight-man boats are of the following dimensions:—Length on keel 16 ft. 6 ins., length over all

28 ft. 6 ins., beam, extreme, 6 ft. 6 ins., depth at stem head 6 ft., depth at lowest point of gunwale 3 ft., depth at stern post 5 ft. 6 ins. Foremast 15 ft. 9 ins., foreyard 6 ft., mainmast 13 ft. 6 ins., mainyard 10 ft. The foremast can be stepped either at the fore thwart or at the second thwart, the former is said to be the more usual place, and when thus stepped, the boat, it is said, will "look" pretty nearly in the wind's eye.

The oars, eight in number, are each 11 ft. 9 ins. long, and are pulled double banked.

The whaling implements consist of:—

1. Two lances (hvalvaben) each 12 ins. long and 4 ins. broad, fixed on wooden shaft 6 ft. long, and to which a thin line is attached.
2. Two hooks (söhnateroge) and lines for towing the whales when dead.
3. A fishing lead or stone about 3 lbs. in weight slung on to a long line, and used for anchoring or deadening the boat's way, also used as a missile for driving the whales ashore into a whale-voe (hvalvaag) *i.e.*, one with a gradually sloping bottom of loose sand or mud.

The Shetland sixern, the Fair Isle skiff, the North Isles (Orkney) yawl, and the Faroese boat models are exhibited together, in order to show the descent of the fishing boats of the present day, belonging to the islands of the Western "haaf" from the "landskip" of Viking times. The "styri" or rudder of the Viking ships seems to have survived in the Färoes till the present century, as Landt, in his "Description of the "Feroe Islands," says of the Färoes boats of his day :—Few of these boats are built with a rudder, they are generally steered by means of the oars, yet some of them are furnished with what is called "stuiri," which is an implement like a short oar, with which the master steers the boat when necessary.

223. WHOLE MODEL rigged. Fishing boat. Scale ½ in. to 1 ft. The drift fishing boat "CELT," built 1883, Fellows & Son, Yarmouth.

Presented by G. C. Bompas, Esq. 1883.

Note.—The length of the "CELT" is 59·5 ft., breadth 16·8 ft., depth 7·7 ft. Register tonnage 35·98 tons.

She is designed for drift fishing, principally in the North Sea. The number of hands employed varies from six when trawling to nine when fishing for herrings. A steam capstan is fitted to assist in hauling in the nets, &c.

224. WHOLE MODEL. Fish carrying boat. Scale ⅜ ins. to 1 ft. Boat employed in the North Sea for conveying fish from the trawlers and smacks to the steam cutters. Designed and built, 1883, by A. McMillan, Hull.

Presented by G. C. Bompas, Esq. 1883.

Note.—The model represents a boat of the following dimensions:—Length 17 ft., breadth 6 ft. 6 ins., depth 2 ft. 9 ins. The boat will carry about two tons, and requires two men to manage her.

The model shows also life-saving apparatus, *i.e.* an air tank that will float should the boat be stove in and sinking. A tank with a supply of oil for use in rough weather to calm the sea astern and prevent it breaking into the boat. A line fastened alongside the keel, which, should the boat turn over, enables the boat's crew to hold on.

225. WHOLE MODEL rigged. Fishing boat. Scale 1 in. to 1 ft. Mount's Bay lug-sail boat, launched 1878. John Blewett, Newlyn, Penzance.

Presented by G. C. Bompas, Esq. 1883.

Note.—The model represents a lugger rigged boat of about 20 tons register, engaged, according to the season, in fishing for mackerel, herrings, and pilchards, by drift nets. The crew consists of six men and a boy.

Length of vessel 47 ft. over all, breadth 13 ft. 6 ins., depth 7 ft.

Some years ago one of these Mount's Bay boats sailed out to Australia with a six-man crew.

226. WHOLE MODEL. Fishing boat on a scale of 1 in. to 1 ft. Mevagissey lug-sail boat, launched May 1884. H. Roberts, Mevagissey.

Presented by G. C. Bompas, Esq. 1883.

Note.—Model represents a boat of the following dimensions:—Length 38 ft., breadth 11 ft. 1½ ins., depth 6 ft. 2 ins. Register tonnage 11 tons. Fishing boats of this description are adapted for the drift fisheries. When engaged in mackerel fishing each boat employs a crew of five hands, for summer pilchard fishing three hands, and for winter pilchard fishing and herring fishing five hands make the crew. The fishing ground is off the Cornish coast (Mevagissey).

227. WHOLE MODEL. Fishing boats. Land's End Seine fishing boat and Follyer, with seine nets, &c. W. Williams, Mousehole, Penzance.

Presented by G. C. Bompas, Esq. 1883.

228. WHOLE MODEL full rigged. Fishing boat. Scale 1 in. to 1 ft. A Guernsey mackerel fishing boat. S. Bishop, Bristol.

Presented by G. C. Bompas, Esq. 1883.

Note.—These boats are about 12 tons burden and three beams length. They carry a crew of six men.

229. WHOLE MODEL. Fishing boat. Lug-rigged Manx fishing boat of 48 to 50 ft. keel, for herring fishing. Thomas Watson, Peel, Isle of Man.

Presented by G. C. Bompas, Esq. 1883.

229A. WHOLE MODEL. Fishing boat. Dandy-rigged Manx fishing boat of 48 to 50 ft. keel, for herring or mackerel fishing. Thomas Watson, Peel, Isle of Man.

Presented by G. C. Bompas, Esq. 1883.

230. WHOLE MODEL, rigged. Fishing boat. Scale ½ in. to 1 ft. A Manx fishing boat. Length of keel 48 ft., length over all 56 ft., breadth 14 ft. 9 ins., depth of hold 8 ft. 3 ins. R. Harrison, S. Mary's, Isle of Man.

Presented by G. C. Bompas, Esq. 1883.

231. WHOLE MODEL, rigged. Fishing boat. A Southport shrimping boat with nets, To show how four nets are worked. Richard Ascroft, Southport, Lancashire.

Presented by G. C. Bompas, Esq. 1883.

232. WHOLE MODEL. Fishing boat. Scale 1 in. to 1 ft. A Scotch deep sea or herring boat. Tons register 25. A. Taylor, Sandhaven, Fraserburgh, N.B.

Presented by G. C. Bompas, Esq. 1883.

Note.—The model is designed to illustrate several improvements proposed for Scotch fishing boats.

The mast works on a pivot about three ft. from the deck, and is hoisted and lowered with a winch by two men, the tackle being under the deck. The stays are so constructed that they remain always tight, either when the mast is set or being hoisted or lowered. The lug-sail is fitted aft the mast, so that the boat can be tacked without lowering the sail, The spanker is fitted with a short boom, and can be used as a trysail in bad weather.

At the forward part of the vessel a permanent rail is fitted, and at the aft end is a portable rail which can be removed while the nets are being shot or hauled, and replaced when the nets are on board.

The crew consists of six men and a boy, but only two men are required to hoist the sails and put about or tack the boat.

The boats are generally fitted out for herring fishing, and at other times for cod and ling fishing.

233. WHOLE MODEL, rigged. Fishing boat. A Heligoland fishing sloop. Paul A. Jaspers, builder.

Presented by G. C. Bompas, Esq. 1883.

Note.—The fishing industry of Heligoland is carried on by a fleet of open boats which consist of sloops, rudder-boats, middle-boats and lobster boats.

All these are built entirely of oak, and are all flat-bottomed, to enable them to be beached, and are sailed with lee-boards.

The sloops represented by model are 31 ft. long, 9 ft. beam, 5 ft. deep, draw 2·3 ft. water, and are valued at 250*l.* each.

They are rigged with sprit and foresail, with two jibs, as they carry no bowsprit, a spar is used temporarily for setting the jib, and when running free this spar is rigged out on the beam with the jib set on it.

They all carry eight days' provisions and water, two anchors, a hemp cable, and from seven to nine cwt. of stone ballast.

In case the weather is too bad for them to get back, they anchor, take the mast down, and ride out the heaviest gale, one man constantly baling. The other boats are all rigged with standing lug.

234. WHOLE MODEL, rigged. Fishing boat on a scale of 1 in. to 1 ft. A Norse transport vessel (Nordlands Jægt) employed in carrying cured fish.

Owre & Steene, Trondhjem, Norway.

Presented by G. C. Bompas, Esq. 1883.

Note.—The model represents a vessel of the following dimensions:—Length on deck 67 ft. 6 ins., breadth 28 ft. 5 ins., depth of hold 10 ft. 9 ins. Draught of water abaft 10 ft. 6 ins., draught forward 9 ft. Tons, 80. The vessel will carry 80,000 lasts of salted fish, weighing 105,800 kilogrammes.

235. WHOLE MODEL. Fishing boat. A Nordlands Jægt used for the transport of fish. The Handels Foreningen (Commercial Association), Trondhjem, Norway.

Presented by G. C. Bompas, Esq. 1883.

236. WHOLE MODEL, rigged. Fishing boat. Norse herring drift-net boat with nets and outfit. The Handels Foreningen (Commercial Association), Trondhjem, Norway.

Presented by G. C. Bompas, Esq. 1883.

237. WHOLE MODEL, rigged. Fishing boat. Swedish boat used for seal hunting in the Baltic. South Westrobothnia.

Presented by G. C. Bompas, Esq. 1883.

238. WHOLE MODEL, rigged. Fishing boat. Vestrobothnia Swedish net boat.

Presented by the Commissioners for Sweden at the International Fisheries Exhibition. 1883.

239. THREE MODELS. Fishing boats. Swedish (Bohuslän) fishing boats.

Lent by Dr. Oscar Dickson, Gothenburg. 1883.

240. WHOLE MODEL, rigged. Fishing boat. Swedish (Bohuslän) mackerel fishing boat.
Lent by Dr. Oscar Dickson, Gothenburg. 1883.

241. TWO MODELS, rigged. Fishing boats. Russian boats employed in the cod fisheries and for walrus hunting on the Moormen coast, Gulf of Bothnia.
Presented by the Russian Commissioner for the International Fisheries Exhibition. 1883.

Note.—There is much similarity of type in these Moormen coast fishing boats to the Scandinavian, Orkney, Shetland, and Faroe Isles fishing boats.

242. WHOLE MODEL, full rigged. Fishing boat. Australian fishing boat with centre-board. Built, 1882, by Donnelly and Sullivan, Sydney, New South Wales.
Presented by the Commissioners for New South Wales at the International Fisheries Exhibition. 1883.

243. WHOLE MODEL, rigged. Fishing boat. Scale 1 in. to 1 ft. Tasmanian fishing smack with well.
Presented by the Commissioners for Tasmania at the International Fisheries Exhibition. 1883.

244. WHOLE MODEL, rigged. Fishing boat. Scale 1 in. to 1 ft. Tasmanian fishing boat with well.
Presented by the Commissioners for Tasmania at the International Fisheries Exhibition. 1883.

245. WHOLE MODEL. Fishing boat. Scale 1 in. to 1 ft. Tasmanian seine fishing boat.
Presented by the Commissioners for Tasmania at the International Fisheries Exhibition. 1883.

246. HALF MODEL. Fishing boat. Steam screw fishing tug "JERSEY LILY."
Presented by Mr. Samuel Wilmot, Canadian Commissioner at the International Fisheries Exhibition. 1883.

Note.—This model is fitted in a glass case with a coloured background, and represents the steam vessel at work on the Canadian lakes, hauling in and paying out her nets.

247. PHOTOGRAPH. Steam fishing trawler "SOUTHESK." Built of steel at South Shields, 1885.
Lent by Mr. J. T. Eltringham, Stone Quay Works, South Shields. 1887.

Note.—The screw trawler "SOUTHESK" is 120 ft. long, 21 ft. wide, and 11 ft. 6 ins. deep. Register tonnage 50 tons. Her screw propeller is driven by compound surface-condensing engines of 320 indicated horse-power, constructed by J. P. Rennoldson & Sons, South Shields. A multitubular boiler supplies steam at a working pressure of 100 lbs. per square inch. The crew consists of about ten hands. The fishing ground is off the East coast of Scotland.

For other objects lent by Mr. Eltringham, see pages 60, 89, 169.

CLASS I.

Yachts.

SAILING YACHTS.

250. WHOLE MODEL (on about ¼ in. scale) of the schooner yacht "AMERICA." Length 95 ft., beam 22 ft., draft forward 7 ft., aft 11 ft. Tons 210. Built 1851. Designed by Mr. Steers, New York. Rebuilt by Mr. Henry Pitcher at Northfleet.

Lent by the late Mr John Scott Russell, F.R.S. 1868.

Note.—The "AMERICA" yacht was, during the early part of the Civil war in America, 1860–1864, sunk by the Federals. This is the famous yacht which came over from America in 1851 to challenge the yachts of England, and beat the "TITANIA" 4 minutes and 45 seconds in a run of 20 miles before the wind, and 45 minutes returning by the wind.

The advantage of the "AMERICA" may in some measure be attributed to her having cotton canvas instead of flax, and to the very superior manner in which her sails were cut, together with the fact that her tonnage was about double that of the "TITANIA."

251. HALF BLOCK MODEL designed and built by Messrs. Watkins & Co. for a racing cutter yacht on clipper lines. The "BONITA." Tons 10.

Lent by Messrs. Watkins & Co., Blackwall, E. 1877.

251A. HALF BLOCK MODEL designed by Messrs. Watkins & Co. for a yawl yacht on clipper lines. The "MERSEY." Hon. F. Stanley owner. Tons 40. Built 1875.

Lent by Messrs. Watkins & Co., Blackwall, E. 1877.

For other models lent by Watkins & Co., see page 100.

252. WHOLE MODEL, full rigged. Scale 2 ins. to 5 ft. Fore and aft schooner yacht. Tons 390.

Presented by Mr. A. Humphrys. 1878.

252A. WHOLE MODEL, full rigged. Self acting and sailing cutter yacht.

Presented by Mr. James E. Walton, 339, Amherst Road, N. 1880.

Note.—Actual length of hull 2 ft. 6 ins., breadth 10 ins., depth of hold 5 ins., giving proportions of breadth one-third the length, depth half the breadth, length normal. The yacht is on the lines of a mackerel.

253. WHOLE MODEL. Cutter sailing yacht, wood construction. Built .

James D. Rennie, Greenock. 1881.

Note.—This model on a scale of $\frac{3}{4}$ in. to 1 ft. represents a yacht 102 ft. in length, 23 ft. 6 ins. in breadth, 14 ft. 6 ins. depth. Registered tonnage 230.

254. WHOLE MODEL. The cutter racing yacht "FORMOSA." 103 Tons. Built 1879, by Charles Ratsey, Cowes. Scale of model $\frac{1}{2}$ in. to 1 foot.

Lent by Mr. A. R. Ricardo, London. 1883.

Note.—The model is full rigged with planned sails and correct in every detail of the original. It was made by N. J. Pope, H.M.'s Coastguard, Hastings.

255. HALF BLOCK MODELS. Six half block models, mounted. The following pleasure yachts:—

The screw steam yacht "ZENOBIA." 1874. 148 tons.
120 ton cruising schooner.
20 ton racing cutter, "LOUISE." 1879.
26 ton light draught cruising cutter.
20 ton cruising cutter, "VANDA." 1882.
83 ton cutter yacht.

Messrs. Alfred Payne and Sons, Southampton. 1882.

256. WHOLE MODEL of a modern cutter yacht, rigged. Scale $\frac{1}{2}$ in to 1 ft.

Lent by Mr. H. L. Hooper, Southgate. 1877.

Note.—The detail of the rigging of this yacht is complete. The model represents a vessel of about 60 ft. long. by 12 ft. beam.

Steam Yachts.

258. Half Block Model. Scale ½ in. to 1 ft. The screw steam yacht "Emily." Tons Y.M. 35. Built 1879 by Messrs. Forrestt and Son, Limehouse. Length 72 ft. 3 ins., breadth 10 ft. 3 ins., depth 4 ft. 9 ins.

Lent by Mr. Loftus Perkins, 19, Queen Victoria Street, E.C. 1881.

Note.—The three-cylinder inverted compound condensing engines and boiler of the yacht "Emily" were designed for working on Mr. Perkins' extreme high pressure steam system of 300 to 400 lbs. per sq. in. at boilers, and were constructed by Greenwood and Batley, Leeds.

259. Half Block Model. Scale ¼ in. to 1 ft. Screw steam yacht "Anthracite." 70 tons. Built 1878 by Schlesinger, Davis, & Co., Wallsend, Newcastle. Length 86 ft. 4 ins., breadth 16 ft. 1 in., depth 10 ft. 2 ins. The three-cylinder inverted compound condensing engines and boilers by Hawks, Crayshaw, and Sons, Gateshead. The boilers constructed for a steam pressure of 400 lbs. per square inch.

Lent by Mr. Loftus Perkins, 19, Queen Victoria Street, E.C. 1881.

Note.—The yacht "Anthracite" crossed the Atlantic in 1880, London to New York, under steam, in 18 days. Her boilers were subjected to a test hydraulic pressure of 2,500 lbs. per sq. in. The engines have cylinders 8, 16, and 23 ins. diameter, stroke 15 ins., speed 105 revolutions per minute. Speed of yacht 10 knots per hour.

260. Half-Block Model of the steam screw yacht "Cornelia," built 1868 for Earl Vane, by the Palmer's Shipbuilding Company, Limited. Length 176 ft., breadth 20¾ ft., depth 14 ft. Tonnage, gross, 212. Horse-power 50 nominal. Speed 11 knots per hour. Scale $\frac{1}{48}$th full size.

Palmer's Shipbuilding Company, Limited, Newcastle-on-Tyne. 1874.

261. Whole Model. The Imperial Russian screw steam-yacht "Livadia." 1880. Scale ¼ in. to 1 ft. Length over all 266 ft., breadth, water-line, 153 ft., depth to awning deck 36 ft. 7 ins. Tons Y.M. 11,802. Indicated horse-power 10,500. Speed 14 knots per hour. Built by J. Elder, & Co., Glasgow.

Purchased. 1883.

Note.—The "Livadia" is propelled by three four-bladed screws, which are driven by three sets of compound condensing engines, each having three cylinders, one of 60 ins.

two of 78 ins. diameter, with a stroke of 3 ft. 3 ins. The yacht is lighted throughout by electric light on the Jablochkoff system. She was iron-built from Russian designs.

262. HALF-BLOCK MODEL. Scale of ½ in. to 1 ft. Screw yacht "ROSALIND." Length over all 68 ft., breadth, extreme, 11 ft. 6 ins., depth, moulded, 6 ft. 1 in. Engine cylinders 8 and 14 ins. diameter. Stroke 12 ins. Fitted with Cochran's boiler, 5 ft. diameter by 9 ft. 9 ins. long.

Lent by Messrs. Cochran & Co., Birkenhead. 1885.

For models of steam launches see page 101.

263. WHOLE BLOCK MODEL. Steam screw yacht "UNDINE." 414 tons. Built of iron, 1856, by John Scott Russell & Co., Millwall, for the Duke of Sutherland. Engines by James Watt & Co., Soho, Birmingham.

Transferred from the Patent Museum. 1885.

264. WHOLE MODEL. Screw yacht "SALAMANDER." Built by the exhibitors 1885.

Lent by Messrs. Schlesinger, Davis, & Co., Wallsend, Newcastle-on Tyne. 1887.

Note.—The length of the screw yacht "SALAMANDER" is, over all, 130 ft., breadth, moulded, 20 ft., depth, moulded, 10 ft. 6 ins. Tonnage Y.M. 211. Working pressure in boiler 450 lbs. to sq. in., which is constructed on Herreschеff's system, and has borne a test proof of 2,000 lbs. per sq. inch. The engines are high speed running, of the Loftus Perkins' pattern.

265. PHOTOGRAPH. Steel-built screw yacht SAREEA." Built and engined, 1886, by the exhibitors, for the Egyptian Government's Coastguard Service.

Presented by Messrs. Ross and Duncan, Whitefield Works, Govan, Glasgow. 1887.

Note.—The length over all of the "SAREEA," is 68 ft., beam 12 ft., depth, moulded, 7 ft. The structural work of the hull is of mild steel. Both hull and machinery were built under Lloyd's survey for the 100 AI. yacht class. Mean speed on trial trip 11 miles per hour. Indicated horse-power 120. The engines, on the compound surface condensing system, have cylinders 10 and 20 ins. diameter, stroke 14 ins. A double furnace steel boiler supplies steam at 100 lbs. per square inch pressure.

For engines and propeller of the "Sareea," see pages 203, 246.

266. HALF BLOCK MODEL. Screw steam yacht "PUCK." Built of steel, 1880, at Drogheda, for General W. S. Cooper.

Lent by Thomas Grendon & Co. 1888.

Note.—The screw steam yacht "PUCK" is of the following dimensions:—Length over all, 61 ft. 3 ins., breadth 9 ft. 6 ins. Registered tonnage 25. Nominal horse-power 25. Speed 16 miles per hour. The boiler is of steel and tubular, 8 ft. 3 ins. long, 5 ft. 6 ins. diameter. Its working pressure of steam 75 lbs. per square inch.

For other models lent by Thomas Grendon & Co., see pages 67, 68, 268.

267. DRAWING. Longitudinal section of the screw steam yacht "GRACE DARLING." Built of steel and engined by the exhibitors 1887.

Lent by Messrs. Fleming and Ferguson, Paisley. 1888.

Note.—The "GRACE DARLING" is 239 tons T.Y.M. Length, over all, 157 ft.; breadth, moulded, 19 ft. 6 ins.; depth, moulded, 11 ft.

The screw engines, having four cylinders, driving two cranks, are triple expansion, compound, condensing engines. The cylinders are 10, 14, 20, and 28 inches diameter, with a stroke of 20 ins. A steel boiler, 10 ft. diameter and 9 ft. long, supplies steam at a pressure of 180 to 190 lbs. per square inch. The yacht is electric lighted throughout, and is furnished with a fresh water distilling apparatus.

CLASS I.

River Steamboats and Canal Boats.

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269. WHOLE MODEL. Mersey river ferry paddle-wheel steamer "CHESHIRE." Iron, built at Liverpool in 1863 by H. M. Lawrence & Co., from designs by Mr. George Harrison, M.I.C.E., Liverpool. 1864.

Note.—The "CHESHIRE" is employed on the Mersey on the Woodside ferry service, Liverpool to Birkenhead. She is licensed to carry 1,620 passengers. The steamer is double-ended, and runs at equal speed either end first. Her hull dimensions are 150 ft. by 30 ft. by 12 ft. Extreme breadth over sponsons on upper deck 48 ft. Draught 6 ft. Two sets of independent engines drive the paddle-wheels.

Nominal collective horse-power 130. There are many similar ferry steamers employed on the Mersey; screw propeller vessels having single, twin, or quadruple propellers, are, however, gradually superseding the paddle-wheel steamers.

270. WHOLE MODEL of the iron paddle-wheel river steamer "QUEEN." Built and fitted with engines by J. and G. Rennie, 1842. Length 160 ft., depth 9 ft. Speed between 17 and 18 miles per hour, which exceeded that of any vessel on the Thames.

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

271. MODEL of the "JOHN RANDOLPH," 1834. Paddle steamer. Length 110 ft., breadth 22 ft., depth 7 ft. 6 ins. 249 tons. 60 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—The first iron steamer ever seen on American waters. Built at Birkenhead, taken to pieces, shipped at Liverpool, rivetted together on the Savannah river, where for many years after she did service as a tug boat.

272. HALF BLOCK MODEL of the "GARRYOWEN," 1834. Paddle steamer. Length 130 ft., breadth 21 ft. 6 ins., depth 9 ft. 3 ins. 249 tons. 90 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Paddle steamer, built for the City of Dublin Steam Packet Company, for the navigation of the Lower Shannon, and the largest iron vessel built at the time. After 30 years' service in Ireland the machinery was taken out of her, and she was made into a sailing ship.

About the year 1851, at Mr. Laird's suggestion, this vessel was placed at the disposal of the Admiralty to enable them to institute a series of experiments on the variation of the compass in iron vessels, which were conducted by Capt. Johnson, R.N., and subsequently elaborated by the experiments carried out by Professor Airy on the General Steam Navigation Company's steamer "RAINBOW," built by Mr. Laird in 1837.

273. HALF BLOCK MODEL of H.E.I.C. paddle steamers "EUPHRATES" and "TIGRIS," 1834. Length 105 ft., breadth 19 ft., depth 7 ft. 6 ins. Tons, 179. 50 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Built for the Hon. East India Company for General Chesney's expedition for the exploration of the River Euphrates. These vessels were built by Mr. Laird at Birkenhead, 1834, then taken to pieces and shipped to the

coast of Syria, and after having been carried across the desert by camels, they were put together and launched on the banks of the Euphrates by artisans sent from Birkenhead for the purpose.

Three similar vessels of very light draught, the "NIMROD," "NITOCRIS," and "ASSYRIA," of 153 tons, each carrying two 9-pr. pivot guns, were built for the navigation of the Tigris and Euphrates a few years later.

274. HALF BLOCK MODEL. Small screw steamer "MAB." The fastest steamer on the River Neva of her time. Built in 1874, of brass, by George Baird, St. Petersburgh.

Length	48 ft.
Breadth	6 ft. 6 ins.
Depth at side	3 „ 6 „
Draught	1 „ 7 „
„ over screw	2 „ 9 „
Speed	19 miles per hour.
Diameter of high pressure cylinder	7 ins.
„ low „ „	11 „
Stroke	8 „
Working pressure	120 lbs.
Revolutions per minute	600

Lent by Mr. George Baird, St. Petersburgh. 1876.

275. Drawing of the paddle steamer "ELIZABETH," built by Charles Baird in 1815, and run on the river Neva, St. Petersburgh.

Lent by Mr. George Baird, C.E., St. Petersburgh. 1876.

Note.—She was constructed out of a barge, and the chimney was of brick. The floats of the paddle-wheels were kept in a vertical position by means of shafts and mitre wheels. Scale of drawing $\frac{1}{4}$ inch to the ft.

276. Drawing of paddle-wheel steamer, built by Charles Baird in 1817. To carry passengers between Petersburgh and Cronstadt. Showing end view, longitudinal view, plan, and longitudinal section.

Lent by Mr. George Baird, St. Petersburgh. 1876.

Note.—References to drawing.

A. Steam engine.
B. Boiler.
G. C. Crank shafts on either side, with fly-wheel.
D. D. Toothed wheels driving paddle-wheel.
E. E. Paddle-wheels with floats revolving 50 turns per minute, by which the vessel is propelled.
F. Funnel leading from furnace serving in place of a mast.
G. G. Fore and aft cabins.

H. H. Side decks, to protect the wheels from the blows of the waves.
I. I. Paddle-boxes.
K. L. Staircase and rudder.
Scale of drawing, ¼ in. to 1 ft.

277. HALF BLOCK MODELS representing lines and forms of light-draught vessels for river navigation in British Columbia, 1860.

Presented. 1876.

Note.—These models represent vessels in British Columbia, about 1860.

The "CARIBO" side wheel steamer. Built at Victoria for the Fraser River trade.

The river steamer "GOVERNOR DOUGLASS." Built at Victoria. Tons 200. Draught 3 feet.

Centre-board schooner. Built at Victoria for the British Columbia coasting trade.

278. HALF BLOCK MODEL of the light-draught iron paddle steamer "ALOUNGPYAH." Built 1875. Tons 825 B.M. Horse-power 150, nominal.

Lent by R. Duncan & Co., Port Glasgow. 1876.

Note.—The half model of this paddle steamer illustrates the method of carrying a spar deck which has a roof, covering all. Also the detail of upper deck fittings. Her length is 245 feet, breadth 26 feet, depth 8 feet. She carries light goods and passengers, and tows two iron barges each 190 feet long, carrying 300 to 500 tons weight of cargo, according to the season of the year. The engines are compound diagonal, with cylinders 31 and 53 ins. diameter. Stroke 54 ins. Two horizontal cylindrical tubular boilers supply steam at 70 lbs. per square in. The coal bunkers carry 100 tons of coal, sufficient for a voyage from Rangoon to Mandalay and back, 1,400 miles. She was built by R. Duncan & Co. for the navigation of the river Irrawaddy, from Rangoon in British Burmah, to Bhamo in Upper Burmah, nearly 1,000 miles.

279. HALF BLOCK MODEL. River screw tug. Treble screw tug.

Lent by Mr. George Scott, Govan, Glasgow. 1877.

Note.—This treble screw tug, built of iron, for river use, is fitted with a pair of screws (twin screws) at the stern, and one screw at the bow in her fore foot.

Tug boats, fitted with two, three, and four screw propellers, are working on the principal British and Irish rivers. The screws are sometimes placed forward as well as aft.

280. WHOLE MODEL. Light draught paddle steamer "Doo Woon." The Irrawaddy River Steam Flotilla

Company. Built of iron, 1880, by W. Denny and Brothers. Length 250 ft., breadth 30 ft., depth 9 to 7 ft. Scale of model ¼ in. to 1 ft.

Messrs. W. Denny and Brothers, Dumbarton. 1881.

Note.—The machinery of the "Doo Woon" by W. Denny & Co. The engines are two-cylinder diagonal compound, 34 and 59 ins. diameter. Stroke 4 ft. 6 ins. Paddle-wheels of iron; with feathering floats, make 40 revolutions per minute. Two iron tubular boilers 12 ft. 6 ins. diameter, and 9ft. 8 ins. long each, supply steam at 70 lbs. per square in.

281. WHOLE MODEL. Light draught paddle steamer, "THOOREAH." The Irrawaddy River Steam Flotilla Company. Built of steel by W. Denny and Brothers, 1881. Length 260 ft., breadth 34 ft., depth 9 to 7 ft. Scale of model ¼ in. to 1 ft.

Messrs. W. Denny and Brothers, Dumbarton. 1881.

Note.—The machinery of the "THOOREAH," constructed by W. Denny & Co., is of precisely the same description as that fitted to the "Doo Woon" paddle steamer.

The paddle steamers "Doo Woon" and "THOOREAH" were employed as gunboats and transport craft on the River Irrawaddy in 1885 in the service of the British forces in Burmah. The paddle steamer "IRRAWADDY," built 1876 at Calcutta, was also employed at same time.

282. HALF BLOCK MODEL. Iron saloon paddle steamer QUEBEC," for service on the River St. Lawrence, Canada. Built, 1864, by Barclay, Curle, & Co. Length 282 ft., breadth 34 ft., depth 11 ft. Tons B.M. 1609. Scale of model ⅛ in. to 1 ft.

Lent by Messrs. Barclay, Curle, & Co., Whiteinch, Glasgow. 1881.

283. HALF BLOCK MODEL. Clyde passenger paddle steamer "MARQUIS OF BUTE." Iron built and engined, 1868, by Barclay, Curle, & Co. Length 196 ft. (keel length 192 ft.), breadth 18 ft., depth 7 ft. 6 ins. Tons 163. Scale of model ¼ in. to 1 ft.

Lent by Messrs. Barclay, Curle, & Co., Whiteinch, Glasgow. 1881.

Note.—The paddle steamer "MARQUIS OF BUTE" has a single cylinder diagonal engine of 85 nominal horse-power. Stroke 60 ins. Cylinder 48 ins. diameter. One haystack steel boiler 12 ft. 7 ins. in diameter, 13 ft. 3 ins. high. Steam pressure 45 lbs. Extreme diameter of feathering float wheels 18 feet 6 inches.

284. HALF BLOCK MODEL. Clyde passenger paddle steamer "LORD OF THE ISLES." Iron built 1877, D. and W. Henderson & Co., Glasgow. Length 246 ft., breadth 24 ft. 2 ins., depth 9 ft. The engines are oscillating cylinder, surface condensing. Cylinders 46 ins. diameter. Stroke 5 ft. 6 ins. Diameter of paddle wheels 20 ft. 6 ins. Two haystack boilers supply steam at 45 lbs. per square inch.

The Glasgow and Inveraray Steam Packet Company, 5, Oswald Street, Glasgow. 1881.

285. WHOLE MODEL. Double-ended, four-screw, Mersey river steam ferry boats "CROCUS" and "SNOWDROP." For service between Liverpool and Wallasey.

Lent by Messrs. Flannery and Fawcus, 17, Water Street, Liverpool. 1885.

Note.—These vessels were built, 1885, by Allsup and Sons, Preston, from designs by Messrs. Flannery and Fawcus. Length 130 ft., breadth 35 ft., depth 11 ft. 5 ins. Both vessels are constructed of Landore Siemens' steel throughout, and each is divided into 18 water-tight compartments.

Each boat is built to run either end first, and is fitted with four screws (two at each end), driven by two sets of complete engines on the compound inverted cylinder surface-condensing system. Cylinders 18 and 37 ins. diameter. Stroke 24 ins. Two steel boilers supply steam at 100 lbs. per square inch pressure. Speed on trial 11 knots per hour.

With the model is lent a coloured drawing of the S.S. "CROCUS," showing profile, longitudinal section, and plan of main deck.

The "WALLASEY," Mersey river ferry steamer, iron, built in 1882 by Allsup and Sons, Preston, is a similar four-screw propeller vessel.

286. COLOURED DRAWING. Longitudinal elevation, section, and plan of main deck of the double-ended, four-screw, Mersey river steam ferry boats "CROCUS" and "SNOWDROP."

Lent. by Messrs. Flannery and Fawcus, 17, Water Street, Liverpool. 1885.

287. WHOLE MODEL of the screw tug "VICTOR." Built, 1884, by W. S. Cumming, Blackhill Dock, Glasgow. Engined by Ross and Duncan, Govan.

Messrs. Duncan Brothers, Queen Victoria Street, E.C. 1885.

Note.—The tug is constructed entirely of steel, has three bulkheads, and deck of teak. Length between perpen-

diculars 45 ft., breadth, moulded, 10 ft., depth 6 ft. 6 ins. Height of bulwarks 1 ft. 6 ins.

The engines are direct-acting inverted cylinders compound surface-condensing, with horizontal condenser. Slide valves driven by Bremme's patent valve gear. The air, circulating, feed, and bilge pumps are worked direct from the crosshead.

The boiler is of the single furnace return multitubular type, constructed entirely of Siemens' best mild steel according to Lloyd's requirements for a working pressure of 80 lbs. per square inch.

288. WHOLE MODEL of the American river side-wheel steamer "EMPIRE," of the New York and Albany line of steamers running on the River Hudson.

Presented by Mr. D. Lapraike. 1868.

Note.—This model shows particularly the ship's construction, the disposition of the passenger accommodation, and the emplacement of the boilers, steering wheel house, &c.

289. LITHOGRAPH. The American high-pressure working steamboat "MAYFLOWER." First class packet between St. Louis and New Orleans on the Mississippi river.

Transferred from the Patent Museum. 1886.

Note.—An American print, coloured. Exhibited to illustrate the plan, elevation, and style of American side-wheel steamers. The "MAYFLOWER," is fitted with horizontal or inclined cylinder condensing engines below decks.

290. LITHOGRAPH. The American low-pressure working steamboat "NEW WORLD," running on the Hudson River between New York and Albany.

The following are the dimensions of the "NEW WORLD":—Length, over all, 380 ft., breadth, over all, 85 ft., breadth of beam 50 ft. Diameter of cylinder 76 ins., length of stroke 15 ft., diameter of wheel 46 ft. The accommodation aboard comprises 347 state rooms. 680 berths.

Transferred from the Patent Museum. 1886.

Note.—An American print, coloured. Exhibited to show the plan, elevation, and style of American side-wheel steamers. The "NEW WORLD" is fitted with a condensing, single engine with rocking beam motion, standing high above decks. This style of engine is peculiar to America. It has not been approved with English engineers, although paddle-wheel steamers with a rocking beam engine have been built on the Clyde for service in China.

291. LITHOGRAPH. "A Midnight Race on the River Mississippi." Between the American side-wheel packet

"ECLIPSE" and the mail line side-wheel packet, "NATCHEZ," the latter running between Vicksburgh, Natchez, and New Orleans.

Transferred from the Patent Museum. 1886.

Note.—An American print, coloured. Exhibited to show the style of American side-wheel steamers on the Mississippi river, which are driven by horizontal or inclined engines working with high-pressure steam, and non-condensing. In these speed matches the boilers and the engines are pressed with very great severity.

292. HALF MODEL. Scale ¼ in. to 1 ft. Paddle-wheel tug "FLYING SPORTSMAN." Built of iron at South Shields, 1882.

Lent by Mr. J. T. Eltringham, Stone Quay Works, South Shields. 1887.

Note.—The steam tug "FLYING SPORTSMAN" is of the following dimensions:—Length 122 ft., breadth 20 ft., depth 10 ft. 11 ins. Tonnage, registered, 58. The paddles are driven by surface-condensing side-lever engines of 98 nominal horse-power, constructed by J. P. Rennoldson and Sons, South Shields. The boilers are multitubular and supply steam at a pressure of 45 lbs. per square in. About eight hands form the crew.

The model represents the typical paddle-wheel tugs built at South Shields and other ports for service on the Tyne and other rivers.

For other objects lent by Mr. Eltringham, see pages 60, 77, 169.

293. HALF MODEL. Tyne River passenger paddle-wheel steamer "BEATRICE." Built of steel, and engined by the exhibitors at St. Peters, Newcastle-on-Tyne, 1883.

The Tyne General Ferry Company, Newcastle on-Tyne. 1887.

Note.—The dimensions of the paddle steamer "BEATRICE" are:—Length 103·1 ft., breadth 15·15 ft., depth in hold 6·65 ft., length of engine room 20·8 ft. Register tonnage 40·77 tons. Oscillating engines, having two cylinders of 22 ins. diameter, drive the paddle-wheels. Length of stroke 26 ins. Horse-power 30.

Steam at a pressure of 35 lbs. per square inch is supplied by an Archer's patent multitubular boiler constructed of Weardale steel by the Tyne Boiler Works Company, Low Walker, Newcastle-on-Tyne.

294. HALF MODEL. Tyne River passenger paddle-wheel steamer "ALICE." Built of steel, 1887.

The Tyne General Ferry Company, Newcastle-on-Tyne. 1887.

Note. — The paddle steamer "ALICE" was built and engined at St. Peters, Newcastle-on-Tyne. Her length is 103·4 ft., breadth 15·75 ft., depth in hold 6·8 ft., length of engine room 21·1 ft. Register tonnage 36·79 tons. The paddle-wheels are driven by oscillating engines, having two cylinders 22 ins. in diameter. Length of stroke 26 inches. Horse power 30.

Steam is supplied at a pressure of 35 lbs. per square inch by a multitubular boiler (Archer's patent), constructed of Siemen's-Martin steel, by J. Adamson & Co., Hyde, Manchester.

These river service steamers run from Newcastle to Tynemouth and back. They call at many stations on the journey on both sides of the River Tyne, consequently needing speed and attentive and quick handling. The "Rule of the Road" for the navigation of the Tyne is exceptionally good and stringent.

295. WHOLE MODEL. River passenger paddle-wheel steamers "ROSALIND," "CELIA," and "ORLANDO." Built, 1885, for service on the Thames, between Greenwich and Battersea, by Sir William Armstrong, Mitchell, & Co., Newcastle. Engined on the compound system, with inclined engines, by R. and W. Hawthorn, Leslie, & Co., Newcastle.

Lent by Sir Wm. Armstrong, Mitchell, & Co., Newcastle. 1887.

Note.—These vessels were designed with a view of improving both in accommodation and speed the original Thames river above-bridge service steamers. They differed from the old style of steamboat in having a large and well lit saloon cabin aft, a smaller one forward, and an engine arrangement whereby the engineer controlled the engines from the upper deck immediately under the captain's bridge. The engines are inclined two-cylinder compound, driving both wheels at once. Speed 10½ knots per hour. Displacement of the boat's hull 77 tons.

For other models lent by Armstrong, Mitchell, & Co., see pages 12, 14, 267.

CLASS I.

Ship's Boats.—Life-boats and Life-rafts.—Pleasure Boats.

SHIPS' BOATS.

297. FOUR MODELS of ships' boats built of steel, with screw propellers, and fitted with engines designed especially by John Penn, Esq., F.R.S., of Greenwich. The boats are planned out for the ships of war, designed by the late Vice-Admiral E. P. Halstead, R.N., in 1866. Each carries two guns forward, protected by moveable iron breastplates.

Presented by R. Napier and Sons, Glasgow. 1867.

1. *Launch.*—Length 50 ft. Guns two 10-pounders. Oars 22.
2. *Pinnace.*—Length 45 ft. Guns two 10-pounders. Oars 20.
3. *First Cutter.*—Length 35 ft. Guns two 2-pounders. Oars 14.
4. *Second Cutter.*—Length 30 ft. Guns two 2-pounders. Oars 12.

See also No. 32.

298. SECTION, full size, showing portion of strake and gunwale of steel boats, with metal crutch.

Designed by the late Vice-Admiral E. P. Halsted, R.N., in 1886.

Presented by R. Napier and Sons, Glasgow. 1867.

299. MODEL of H.M.'s steam troopship "ORONTES," on a ¼ in. scale, showing the arrangement of three canting bridges for life-boats, with life-boats built on Lamb and White's principle. Also 10 of Captain J. W. Hurst's patent life rafts, lashed to ship's sides.

Mr. J. White, Cowes. 1873.

300. SERIES of MODELS (nine in number) of life-boats, built on Lamb and White's principle. Originally designed in 1846 for the Peninsular and Oriental Steam Navigation Company, and since used on board H.M.'s steam yachts "VICTORIA AND ALBERT," built 1855; "OSBORNE," built

1843; "FAIRY,' built 1854; "ALBERTA," built 1863; "ELGIN," built 1849.

These life-boats are also adopted for Her Majesty's Navy, and the Coastguard and Trinity House services.

Messrs. J. White & Co., Cowes, Isle of Wight.
1873.

1. Model, on about ¾-in. scale of a life-boat state barge. Presented by the Peninsular and Oriental Steam Navigation Company in 1857 to the Bey of Tunis.
2. Model, on about ¾-in. scale, of the "MARY WHITE" life-boat. Presented to the boatmen of Broadstairs by Mr. Thomas White, of Cowes. Used in rescuing the crew of the ship "NORTHERN BELL" off Kingsgate in January 1857.
3. Model of a life-boat on about ¾-in. scale, as furnished to Her Majesty's ships and services. 1846.
4. Model of 36 ft. life-boat, originally designed in 1846, for the Peninsular and Oriental Steam Navigation Company, and now used on board Her Majesty's ships and transports.
5. Model of a life-boat barge, pulling 14 oars, used in Her Majesty's services. 1859-60.
6. Model of the coastguard life-boat, ordered to be built, and tried in Dingle Bay, Ireland, in 1864, and now (1873) the pattern boat for coastguard service round England, Ireland, and Scotland.
7. Model of a yacht's gig fitted as a life-boat. 1872.
8. Model of a yacht's life-boat adopted by the Royal Yacht Squadron, New Thames Yacht, and other yachting clubs of the kingdom.
9. Model, on about a ¾-in. scale, of the construction, arrangement, and fitting of a life-boat built on Messrs. Lamb and White's principle. 1871.

   The port side of model shows disposition of boat's frame and planking.

   The starboard side fore bow shows the boat as finished; after-end shows the water-tight lining and planking.

The above nine models lent by Mr. J. White, Cowes. 1873.

301. NINE MODELS of life-boats, ships' boats, and others.
Messrs. Forrestt and Son, Norway Yard, Limehouse.
(J. Bond and Son.) Lent 1873.

1. Whale lift-boat, for H.M.'s ship "SYLVIA." Length 28 ft., beam 5 ft. 8 ins., depth 2 ft. 6 ins., ¾-in. scale.
2. Life-boat cutter for H.M.'s ship "SYLVIA." Length 25 ft., beam 7 ft. 3 ins., depth 2 ft. 10 ins., ¾-in. scale.
3. Self-righting cutter life-boat for H.M.'s navy. Length 28 ft., beam 7 ft. 6 ins., depth 3 ft. 2 ins., ½-in scale.

4. Life-boat for Trinity Corporation's screw steamer "VESTAL." Length 25 ft., beam 6 ft., depth 2 ft. 4 ins., ¾-in. scale.
5. Canoe surf-boat for West Coast of Africa. Length 31 ft., beam 6 ft., depth 2 ft. 4 ins., ¾-in. scale.
6. Unsinkable steam launch for ships' and yachts' use. Length 26 ft., beam 6 ft. 6 ins., depth 3 ft. 3 ins., ¾-in. scale.
7. Special hospital surf-boat for service on West Coast of Africa. New design by Messrs. Forrest and Son, for War Department. Scale 1 in. to 1 ft., length 25 ft., depth 2 ft. 3 in., breadth 5 ft.
8. The yawl "KATE," owner E. E. Middleton, who sailed her alone, all round England in 1869. Scale 1 in. to 1 ft., length 23 ft., breadth 7 ft., depth 2 ft. 6 ins.
9. South Sea whale-boat, on a 1 in. to 1 ft. scale, length 30 ft. 6 in., breadth 5 ft., depth 2 ft.

302. MODEL. Scale 1 inch to 1 foot. 30 Feet Gig; built and fitted as a Life-Boat by White, Cowes; for service with H.M.S. "RACOON," 1857.

Lent by H.S.H. Count Gleichen. 1883.

303. MODEL. Ship's Boat; fitted to carry a (swivel) gun.

Presented by Mr. J. S. Tucker. 1865.

LIFE-BOATS.

304. WHOLE MODEL of the Australian life-boat "LADY DALY," built at Adelaide, from designs by Mr. W. Taylor, Government Shipwright at that port, about 1867. Length 43 ft. 1 in., breadth 9 ft., depth, midships, 4 ft. 1 in. Scale ¾ in. to 1 ft. The model was presented to His Royal Highness the Duke of Edinburgh, by the Marine Board of South Australia, in 1868.

Lent by H.R.H. the Duke of Edinburgh. 1869.

304*a*. LITHOGRAPH. Plans and sections of life-boat "LADY DALY," built in Australia. Designed by W. Taylor, Port Adelaide, South Australia, about 1867.

Lent by H.R.H. the Duke of Edinburgh. 1869.

305. MODEL of the life-boat and its transporting carriage, on about a $\frac{1}{10}$th scale, adopted by the Royal National Life-boat Institution, 14, John Street, Adelphi, London.

Designed for the Institution by Mr. Joseph Prowse in 1861.

Lent by the Royal National Life-boat Institution. 1865.

Note.—The form of this boat is that usually given to a whale-boat with a long flat floor amidships, sides straight, raking stem and stern post, diagonally built of two thicknesses of mahogany, and copper fastened. Length, extreme, 33 ft., breadth of beam 8 ft., and depth inside 3 ft. 4 ins. The boat has five thwarts 2 ft. 8 ins. apart, and pulls 10 oars double banked in crutches formed on the thole pin. Extra buoyancy is obtained by the compartments under the deck being filled with water-tight cases packed with cork, detached air cases under the head and stern sheets, and along the sides under the thwarts, and the end are cases in the extremes. It is not probable that this boat could be readily upset, but should such an accident occur, provision is made by the sheer of gunwale, raised air cases in the extremes, weight of cork in the bottom, and the iron keel to cause her to right herself. The area of the delivering valves will enable the boat to readily free herself of all water above the deck in 20 seconds, with 47 persons on board.

This life-boat possesses in the highest degree all the qualities which it is desirable that a life-boat should possess, viz., great lateral stability, speed against a heavy sea, facility for launching and taking the shore, immediate self-discharge of any water breaking into it. The advantage of self-righting if upset, strength, and stowage room for a number of passengers.

The carriage consists of a fore and main body. The latter is formed of a keelway, and of side or bilgeways attached to the keelway, and resting on the main axle, the boat's weight being entirely on the rollers of the keelway. Its leading characteristic is that on the withdrawal of a forelock pin, the fore and main bodies can be detached from each other. The advantages of this arrangement are, that whilst the weight of the boat, when she is launched from the rear end, forms an inclined plane by elevating the keelway, to replace her on the carriage she can be hauled bow foremost up the fore end or longer incline. The bilgeways are needed at the rear end, that the boat may be launched in an upright position with her crew on board, but they are not required at the fore end of the carriage. The boat is hauled off the carriage and launched into the sea by ropes rove through sheeves at the rear end of the carriage, each having one end hooked to a self-detaching hook at the boat's stern, and the other manned by a few persons on the shore, who thus haul the boat and her crew off the carriage and launch them afloat at once, with their oars in their hands; by these means headway may be obtained before the breakers have time to beat the boat broadside on to the beach.

306. WHOLE MODEL, fitted complete, of a life-boat and transporting carriage. *Pattern* 1883.

Lent by the Royal National Life-boat Institution, 14, John Street, Adelphi, W.C. 1885.

Note.—The model is an exact representation of the life-boat which obtained the 600*l.* prize at the International Fisheries Exhibition, 1883.

307. MODEL. Life-boat. Length 36 ft., breadth 7 ft. 10 ins.
Designed and lent by Mr. George Turner, late Master Shipwright, Woolwich Dockyard. 1864.

308. MODEL. Life boat. Length 26 ft.
Proposed and lent by Mr. George Turner, late Master Shipwright, Woolwich Dockyard. 1864.

309. MODEL of Berthon's patent collapsible troop boats. Length 50 ft., beam 14 ft., depth 6 ft. 3 ins. Oars 12. Troops 200.
Designed and lent by the Rev. E. L. Berthon, Romsey, Hants. 1867.

310. WHOLE MODEL. Life-boat, built 1804.
Lent by Mr. James Young, West Dock, South Shields. 1883.
For other models lent by Mr. Young, see pages 64, 69, 150, 218.

311. WHOLE MODEL of a 30 ft. life-boat on Coryton's vertical wave line system, 1868. John Coryton, designer.
Transferred from the Patent Museum. 1885.

312. Life-boat. MODEL of combined life-boat and life-raft. Invented by Parratt and H. Smith.
Contributed.
Transferred from the Patent Museum. 1886.

313. MODEL. Illustrating a mode of fitting boats, either singly or in couples, for the disembarkation of troops, horses, and field guns. This plan was used in the landing of troops in the Crimea, 1854–1856.
Mr. W. Ladd. 1864.

314. Two MODELS showing "Fawcus's" new mode of constructing boats, so that several of the same size and shape may be packed together indiscriminately.
Lent by Mr. G. Fawcus, North Shields, 1866.

315. MODEL of a ship's bulwark fitted with "Fawcus's" patent revolving head davits for lowering and stowing boats promptly.
Lent by Mr. George Fawcus, North Shields. 1866.

316. Two Blocks. "Fawcus's" improved blocks for lowering ships' boats, with necessary fittings for boat's side, thwarts, &c.

Presented by Mr. George Fawcus, North Shields. 1865.

317. Two Models showing arrangements of boat-chocks with sliding wedge pieces, on Mr. Fawcus's plan.

Lent by Mr. George Fawcus, North Shields. 1866.

318. Two Engravings showing elevation, longitudinal section, &c. of improved life-boats, arranged to pack one in the other.

Presented by Mr. George Fawcus, North Shields. 1868.

319. Working Model of Clifford's patent boat-lowering apparatus.

Lent by Mr. A. Battan, Northumberland Alley, E.C. 1874.

Note.—One man performs the operations of unlashing, lowering, and releasing the boat, which cannot cant to one side, nor can one end of the boat enter the water sooner than the other. The boat can be lowered whilst the ship is at full speed, and when she quits the ship, steerage way is left, which enables the coxswain to keep her away clear from ship's side.

320. Horse-shoe boat disengaging gear. Full size. The Rev. J. N. Kilner's patent.

Presented. 1878.

Boat Fittings.

322. Model of the bridges used on board H.M.S. "Orontes" and others, for carrying and launching ships' life-boats.

Mr. John White, Cowes. 1876.

Note.—This is a working model of Mr. J. White's plan, adopted by the Admiralty for H.M.'s ships of war and Indian relief troop ships, for carrying and launching life-boats from ships' upper deck.

The life-boats are carried athwart ships on a rocking bridge originally designed by Messrs. Hire and White. Arrangements are made for openings in ships' bulwarks to allow either end of the rocking bridge to fall down to the edge of ships' upper deck. This gives sufficient inclination to launch the boat either way first. The rocking bridge when canted forms the launching ways.

324. WORKING MODEL of Hill's patent boat-lowering apparatus. Pair of slip hooks, full size. Messrs. Hill & Clark.

Lent by Mr. E. J. Hill, 6, Westminster Chambers, Victoria Street, S.W. 1874.

325. WORKING MODEL of a boat-lowering apparatus, designed by R. J. Fairbridge.

Presented by Mr. R. J. Fairbridge, 57, Neville Road, Stoke Newington, N. 1875.

Note.—The covers for these boats are also specially prepared to serve for stopping leaks, &c.

326. MODEL of Sweeting's patent boat-lowering apparatus with life-boat attached.

F. J. Sweeting, Clyde Dock, Rotherhithe. 1875.

327. MODELS of life-saving apparatus (a boat and raft). Designed by C. Robert.

From the London International Exhibition, 1874. 1875.

328. MODEL of life-raft. Designed by Lieut. R. J. Rowe, R.N. 1875.

329. MODEL of Captain Hurst's Pontoon life-raft, fitted complete.

Lent by Captain J. W. Hurst, M.M. 1868.

329A. MODEL showing mode of fitting Hurst's patent bulwark Life-raft to waist-bulwarks of a ship.

Lent by Captain J. W. Hurst, M.M. 1868.

330. MODEL of a ship's bulwark, showing an improved method for stowing Life-buoys between the bulwark stanchions, along ship's side. Designed by Mr. H. S. Harland, Brompton, Scarborough.

Presented. 1874.

331. YOKE and CRUTCHES for boats; made from a brass gun taken in Sebastopol, 8th September 1855. Presented to the late Capt. Crispin, R.N.

Lent by Mrs. Crispin. 1865.

332. MODEL of upper part of vessel fitted with Life-boat Bridge. Hire and White's patent, 1868.

Contributed 1870.

Transferred from the Patent Museum. 1885.

Note.—This model represents a method for carrying and launching heavy life or other boats on ship board. Hire and

White's plan has been applied to H.M.'s troop and other steamships, as well as to merchant service vessels. The boats are carried athwart ships on rocking stages forming the bridge. When the boats are launched the bridge falls either way end down to port or starboard side as required, the boat slides into the water end first off the inclined plane formed.

333. MODEL of apparatus for disengaging ships' boats. H. T. Lambert's patent, 1859.
Contributed 1861.
Transferred from the Patent Museum. 1885.

PLEASURE BOATS.

335. H.M.'s STATE BARGE. Built in the reign of James I.
Lent by H.M. the Queen. 1883.

Note.—This barge is 63 ft. long, 7 ft. broad, and rows 21 oars. It is oak planked and clincher built. There is a cabin saloon at the after end, fitted and furnished. The barge is highly decorated with carved work and much gilding.

336. MODEL, on 1 in. scale, of the State Barge built in 1807 for the Lord Mayor of London.
Lent by Messrs. Searle & Sons, Lambeth. 1865.

Note.—This model represents the last state barge built for the service of the Lord Mayor of London.

337. MODEL of the Boat built by exhibitors (in 1861) for use of Her Majesty the Queen and His Royal Highness the Prince Consort, during their visit to Ireland and Lakes of Killarney in 1861. The boat was built for Lord Castlerosse. Scale $\frac{1}{8}$-in. to 1 ft.
Lent by Searle & Sons, Lambeth. 1872.

338. MODEL of the eight-oared Outrigger built for the Cambridge University crew in 1860. Length 58 ft., breadth 2 ft. 2 ins., depth 1 ft. $1\frac{1}{2}$ ins.
Built and lent by Messrs. Searle & Sons, Lambeth. 1865.

339. COLOURED DRAWINGS of Racing and Pleasure Boats, built by Messrs. Searle & Sons, Stangate, Lambeth.
Lent. 1873.

Single sculling outrigger gig.
Length 24 ft. Breadth 2 ft. 8 ins.

Sailing canoe.
Length 14 ft. Breadth 2 ft. 8 ins.

Four-oared gig with raised chocks.
Length 24 ft. Breadth 3 ft. 5 ins.

Four-oared outrigger gig.
Length 38 ft. Breadth 2 ft. 5 ins.

Lake boat, sailing or rowing.
Length 20 ft. Breadth 4 ft. 9 ins.

Dinghee.
Length 12 ft. Breadth 4 ft. 6 ins.

Eight-oared racing outrigger.
Length 57 ft. Breadth 2 ft. 2 ins.

Four-oared racing outrigger.
Length 42 ft. Breadth 1 ft. 9 ins.

Pair-oared racing outrigger.
Length 35 ft. Breadth 1 ft. 5 ins.

Single sculling skiff.
Length 22 ft. Breadth 3 ft. 6 ins.

Pair-oared or double sculling gig.
Length 26 ft. Breadth 3 ft. 10 ins.

Sailing canoe.
Length 15 ft. Breadth 3 ft. 2 ins.

Pair-oared or double sculling gig.
Length 24 ft. Breadth 3 ft. 8 ins.

Pair-oared or double sculling gig.
Length 24 ft. Breadth 3 ft. 8 ins.

Randan skiff.
Length 27 ft. Breadth 4 ft. 6 ins.

Pair-oared skiff.
Length 20 ft. Breadth 4 ft. 6 ins.

Racing outrigger with sliding seat.
Length 32 ft. Breadth 1 ft.

Pair-oared or double sculling outrigger gig.
Length 28 ft. Breadth 2 ft. 6 ins.

Sailing gig with centre board.
Length 20 ft. Breadth 4 ft. 6 ins.

Four-oared gig.
Length 35 ft. Breadth 3 ft. 5 ins.

Four-oared gig.
Length 35 ft. Breadth 4 ft. 6 ins.

Rob Roy canoe.
Length 14 ft. Breadth 2 ft. 2 ins.

Single sculling gig.
Length 18 ft. Breadth 3 ft. 6 ins.
Lent by Messrs. Searle & Sons, Lambeth. 1873.

*** These drawings of boats are exhibited in one frame.

340. MODELS. Pleasure and Racing Boats.
Mr. W. H. Biffin, Junior, Boatbuilder, Bedford. 1878.

341. MODEL, ¼ scale. Pleasure Boat.
Mr. David Livie, Boatbuilder, Dundee. 1879.

342. MODEL. Scale 1¾ in. to 1 ft. Pair-oared Thames Pleasure Skiff.
Lent by Mr. H. E. Finn, Isleworth. 1885.

Note.—Model represents a skiff 24 ft. long, 4 ft. wide, fitted with mast, lug-sail, oars, &c., complete.

343. MODEL. Rigged and fitted. Thames Centre-board Gig "RUBY."
Messrs. C. and A. Burgoine, Hampton Wick. 1885.

Note.—The "RUBY" is more of a sailing pleasure boat for the upper Thames than a rowing pleasure skiff; not many of her type are seen.

344. MODEL of an Ice Boat, such as is employed on the Gulf of Finland, the Canadian lakes, &c. The length of the "SOKOL" (FALCON) is about 25 ft., and at her widest part, where the mast rises, she is 12 ft. broad.
Presented by Mr. John S. Anderson. 1865

STEAM LAUNCHES.

346. HALF BLOCK MODEL. Screw steam launch "JACKDAW." Captain R. Goff, owner. Scale ¼ in. to 1 ft. Built by Messrs. Watkins & Co., Blackwall, E.
Lent. 1877.

347. HALF BLOCK MODEL. Twin-screw steam launch "SISCEEPE." Viscount Milton owner. Scale ¼ in. to 1 ft. Built by Messrs. Watkins & Co., Blackwall, E.
Lent. 1877.

348. HALF BLOCK MODEL. Screw steam launch "FLY BY NIGHT." Messrs. Lough Brothers, owners. Scale ¼ in. to 1 ft. Built by Messrs. Watkins & Co., Blackwall, E.
Lent. 1877.

For other models lent by Watkins & Co., see page 78.

349. HALF BLOCK MODEL, on a scale of ½ in. to 1 ft. Screw launch "CRICKET." Length, over all, 40 ft., breadth, moulded, 7 ft., depth 4 ft. Engine cylinders 5 and 10 ins. diameter. Stroke 8 ins. Fitted with Cochran's boiler, 3 ft. 3 ins. diameter, 6 ft. 2 ins. high.

Lent by Messrs. Cochran & Co., Birkenhead. 1885.

350. HALF BLOCK MODEL, on a scale of ½ in. to 1 ft. Twin-screw launch "JEANNE AND LOUISE." Length, over all, 62 ft. 6 ins., breadth, moulded, 12 ft., depth 4 ft. 2 ins. Engine cylinders 5 and 10 ins. diameter. Stroke 8 ins. Fitted with Cochran's boiler, 4 ft. 10 ins. diameter. 8 ft. 6 ins. long.

Lent by Messrs. Cochran & Co., Birkenhead. 1885.

351. HALF BLOCK MODEL, on a scale of ½ in. to 1 ft. Screw launch "MIDGE." Length, over all, 63 ft., breadth, moulded, 12 ft., depth 7 ft. 3 ins. Engine cylinders 10 and 20 ins. diameter. Stroke 14 ins. Fitted with Cochran's boiler, 6 ft. diameter, 9 ft. 9 ins. long.

Lent by Messrs. Cochran & Co., Birkenhead. 1885.

352. HALF BLOCK MODEL, on a scale of ½ in. to 1 ft. Screw launch "ANGLO - EGYPTIAN." Length, over all, 42 ft. 6 ins. breadth, moulded, 9 ft., depth 4 ft. 6 ins. Engine cylinders 8 ins. diameter. Stroke 10½ ins. Fitted with Cochran's boiler 3 ft. 6 ins. diameter by 5 ft.

Lent by Messrs. Cochran & Co., Birkenhead. 1885.

353. HALF BLOCK MODEL, on a scale of ½ in. to 1 ft. Screw launch "DEWSBURY." Length, over all, 25 ft., breadth, moulded, 5 ft. 6 ins., depth 2 ft. 9 ins. Engine cylinder 4½ ins. diameter. Stroke 6 ins.

Fitted with Cochran's boiler, 2 ft. 9 ins. diameter by 3 ft. 6 ins. high.

Lent by Messrs. Cochran & Co., Birkenhead. 1885.

For model of screw yacht "Rosalind," see page 81.

CLASS I.

Craft and Vessels of all kinds not of Modern European Form.

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360. WHOLE MODEL, rigged, of the Viceroy of Egypt's yacht, for the river Nile.

Presented by the Egyptian Commissioner for the Paris Exhibition of 1867. 1868.

361. MODEL, rigged, of a Ceylon boat. Length 14 in., breadth 1 in. Outrigger 7½ ins. over all.

Presented by Mr. T. D. E. Gibson. 1865.

362. MODEL, rigged, of a Cingalese outrigger canoe. Length 2 ft. 2 ins., breadth 1¼ ins. Over all, 10 ins., outrigger.

Lent by Mr. Thos. F. Dodd. 1868.

362A. WHOLE MODELS. Three-masted Chinese junk. Six Chinese boats.

Length of the junk, 21 ins., breadth 5½ ins.
Length of the boats 20 ins., breadth 4 ins.
" " 17½ " " 3½ "
" " 14 " " 4 "
" " 10 " " 2½ "
" " 9 " " 3 "
" " 4½ " " 1½ "

Presented by Mr. J. Pybus. 1868.

363. WHOLE MODEL of a three-masted Chinese junk, rigged. Length of model 4 ft. 2 ins., breadth 11 in., depth 7 ins. The model shows upper deck fittings, hatchways, cooking galley, cabins, &c.

Presented by Mr. W. T. Lay. 1870.

364. MODEL of an ancient Maltese galley, supposed to have belonged to one of the Grand Masters of the Knights of Malta, together with a small painting containing a representation of the galley, and probably of contemporary date with it. Length of model, 6 ft. 2 ins., breadth 14½ ins., depth 6 ins.

Lent by Mr. W. Ladd, late Master Shipwright, Deptford Dockyard. 1864.

365. WHOLE MODEL of a Bombay pleasure boat or yacht, full rigged. Two-masted boat, with lateen sails, running gear, deck fittings, &c. Length of model 3 ft. 7 ins., beam 7¼ ins., extreme depth 7 ins. Scale about 1 in. to 1 ft.

Presented by H.R.H. the Duke of Edinburgh. 1871.

366. MODEL of a Fiji or Feejee double sailing canoe. Rigged, with mast and sails, complete. Made by natives of the Fiji or Feejee islands. Length of major canoe 3 ft. 3 ins.; minor canoe 2 ft. 11 ins. Extreme breadth 18½ ins.

Presented by Sir D. Cooper, F.R.G.S. 1872.

367. MODEL of the Nile dakabeah "MARIANNE." Constructed by Rev. A. J. Foster. Scale ¼ in. to 1 ft.

Lent by Rev. A J. Foster. 1873.

368. TREE CANOE. From the Hudson's Bay Territory. Length 19 ft., breadth 2 ft. 8½ ins.

Presented by the Hudson's Bay Company. 1870.

369. ESQUIMAUX CANOE. From the Hudson's Bay Territory. Length 20 ft., breadth 1 ft. 6 ins.

Presented by the Hudson's Bay Company. 1870.

370. BIRCH BARK CANOE. From the Hudson's Bay Territory. Length 19 ft., breadth 2 ft. 10½ ins.

Presented by the Hudson's Bay Company. 1870.

Nos. 368, 369, 370, *have been withdrawn.*

371. MODEL, rigged, of a Cingalese outrigger canoe. Length, extreme, 3 ft. 4½ ins., beam ¼ in., length of outrigger, 2 ft. 2 ins. extreme, extreme breadth over all 15 ins.

Presented by Mr. W. R. Page, Putney. 1874.

372. MODEL. Native surf boat of Madras. "Masoolah boat."

Presented by Lieut.-Col. John Hoyes. 1878.

Note.—The model represents a surf boat about 30 ft. long and 9 ft. beam.

373. WHOLE MODELS. Native boats of the Indian Ocean.

Presented by Mr. J. W. Mitton-Watson. 1881.

Note.—These models represent a Cingalese outrigger, and a Maldive Island outrigger; and are fitted with masts, sails, and other detail.

374. WHOLE MODEL. A Red Sea Dhow, constructed by Native shipwrights of the African coast, from an original dhow.

Presented by Mr. J. Zohrab, Sutherland Place, W. 1881.

Note.—The model is full-rigged, has planned sails, and is without decks. She represents, it is said, a class of coast trading vessels in the Red Sea, ranging from 90 to 800 tons burden.

375. WHOLE MODEL, rigged, and fitted complete. Japanese trading vessel.

Purchased. 1884.

Note.—The design, construction, hull form, rig, and general detail of this Japanese trading vessel is clearly illustrated by this model, which forms an interesting subject of comparison and consideration in regard to a trading junk of Chinese build and equipment.

376. FISHING BOAT. Full size canoe from Terra del Fuego. Length 17 ft., breadth 2 ft. 9 ins., depth 2 ft. 2 ins.

Presented by the South American Missionary Society. 1883.

Note.—The canoe is constructed of split pieces of wood about ¾ in. thick, and bent from gunwale to gunwale, with flat sides outwards, forming a series of transverse frames, placed close together throughout the length. Both inside and outside are covered with bark; the whole sewn together with split cane. The sides are kept in position by pieces of wood placed athwart and tied on to the gunwale.

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380. A COLLECTION OF INDIAN AND OTHER NATIVE MODELS OF SHIPS, BOATS, RAFTS, &c.

Transferred from the Indian Museum. 1880.

Note.—It is to be regretted that the information regarding these models of ships and boats of native Indian build, is so meagre. Such intelligence about them as was received at the time of their transfer to the Ship Model Collection is however noted.

1. MODEL. Armed vessel, with deck houses and raised poop, and fitted with two masts, boom lug sails, jib, and paddles.— ? Gulf of Persia.

2. MODEL. "JHUMTEE." State barge of the Sind Amirs. A decked sailing vessel with one mast and lateen sail. —Kurrachee, Sinde.

3. MODEL. "COTIA." A decked sailing vessel, with poop. Has two masts and lateen sails.—Kurrachee, Sinde.

4. MODEL. "MUCHWA." An open sailing boat, with mast and lateen sail.—Kurrachee, Sinde.

5. MODEL. "ZOORUCK." An open flat-bottomed sailing boat, with mast and sail.—Kurrachee, Sinde.

6. MODEL. "DOONDA." A flat-bottomed sailing boat, with mast and square sail.—Kurrachee, Sinde.

7. MODEL. Decked pleasure boat, with cabin. Used by Shere Singh, Lahore, Punjab.

8. MODEL. Bridge of boats. Loodiana, Punjab.

9. MODEL. "CATIYAH." A trading vessel, partially decked, with poop, two masts, and lateen sails.—Cutch.

10. MODEL. "BUGLA." A coasting vessel, decked, and fitted with two masts and lateen sails.—Cutch.

11. MODEL. "BUGLA." A decked sailing vessel, with poop, two masts, and lateen sails.—Cutch.

12. MODEL. Cotton Boat. A sailing boat used chiefly for conveying cotton from the shore to ships. Fitted with one mast which rakes forward, lateen sail, and paddles.—Bombay.

13. MODEL. Open Fishing Boat. Fitted with two masts lateen sails, and oars.—Bombay.

14. MODEL. "PATTAMAR." A trading vessel, partly decked and fitted with two masts, lateen sails, and jib.—Bombay.

15. MODEL. River Boat. Partly decked, and with an awning over the after part.—Bombay.

16. MODEL. "JOASEME." A decked vessel with two masts, lateen sails, and jib.—Bombay.

Note.—The model is built from a part of the ship "CORNWALLIS," burnt in 1842.

17. MODEL. "PAMBAN MANCHE." "Snake boat." A long open boat with raised cabin. Used for passengers on the rivers and backwaters.—Cochin, Travancore.

18. MODEL. "JUNGAR." Ferry boat.—Cochin, Travancore.

19. MODEL. Ferry boat; cut from the solid block of timber.—Travancore.

20. MODEL. Small ships' boat.—Travancore.

21. MODEL. "DHONY." A large river boat for sailing and rowing. Has a deck house covered with mats, and is fitted with mast, sail, and oars.—Ceylon.

22. MODEL. Outrigger sailing canoe, with mast and sail. —Point de Galle, Ceylon.

23. TWO MODELS. "MASSOOLAH." A very light clincher-built boat, with the planks sewn together. Used for crossing the surf.—Madras.

24. MODEL. "CATAMARAN." Used by natives for conveying despatches (which are placed in their caps) to shipping off the coast.—Madras.

25. FIVE MODELS. "CATAMARANS." Made of logs.—Madras.

26. MODEL. "KHELA DINGEE." A river boat of slight construction, and covered in with large wickerwork house. It is fitted with lowering mast, square sail, and paddles.—Bengal.

27. MODEL. Fishing boat, partly decked, and fitted with an awning amidships, sail, paddles &c.—Bengal.

28. MODEL. River boat, decked, and fitted with cabin. —Bengal.

29. MODEL. Boat, decked, fitted with raised cabin.—Bengal.

30. MODEL. Common river boat, partly decked, and fitted with an awning.—Bengal.

31. MODEL. "BHELA." A raft made of the stems of "*Aeschynomene paludosa*."—Bengal.

32. MODEL. Cargo boat, decked, with raised hatches in centre.—Bengal.

33. MODEL. "BHAD" or "BHAR PANSI." Used for heavy coarse cargo. A large carvel-built boat, covered in by a matting cabin, and fitted with mast and oars.—Calcutta.

34. MODEL. "BUDGEROW." Boat used for ordinary river voyages. It is partly decked, has a cabin amidships, and is fitted with mast, oars, &c.—Calcutta.

35. MODEL. State boat. Built for the Governors of the English factory at Calcutta. A decked boat with raised cabins, carved figure-head and stern.—Calcutta.

36. MODEL. State boat. Built for the Governors of the English factory at Calcutta. A decked boat with raised cabins, carved figure-head and stern.—Calcutta.

37. MODEL. "DUGOUT." A river boat used on the Hooghly at Calcutta.

38. MODEL. Open river boat.—Calcutta.

39. MODEL. "KHONDA." A flat-bottomed "dugout" boat, used in shallows and lagoons.—Attiah, Bengal.

40. MODEL. "BHED." Common ferry boat, flat-bottomed, and carvel-built.—Attiah, Bengal.

41. MODEL. "SHARANGA." A "dugout" boat, used for shallows.—Attiah, Bengal.

42. MODEL. "KHELNA." A decked pleasure boat, with mat cabin, oars, &c.—Attiah, Bengal.

43. MODEL. "MALAR PANSHI." A large cargo boat. A carvel-built boat with the planks fastened together with iron clamps. Fitted with a lowering mast, and has a mat covering.—Attiah, Bengal.

44. MODEL. "KHELAN." Boat used for carrying produce, and as a passenger boat by the lower orders. An open boat, clincher-built, but with the planks placed the reversed way, *i.e.*, each plank is placed inside the one immediately below it, instead of outside. The planks are fastened with bamboo pegs.—Khoolna, Bengal.

45. MODEL. "DINGHI." An ordinary two-ored "dinghi," used generally in the rivers of Lower Bengal. It is a carvel-built boat (the planks sewn together), partly decked and fitted with an awning.—Serampore, Bengal.

46. MODEL. "BUDGEROW." A decked boat with cabin. —Moorshedabad, Bengal.

47. MODEL. "PARINDU." A decked boat propelled by oars. Amidships is an awning of embroidered velvet.—Moorshedabad, Bengal.

48. MODEL. "CHEEP." A long open boat with bamboo hatches. Amidships is an awning of embroidered velvet. —Moorshedabad, Bengal.

49. MODEL. "SUNGRA." A large flat-bottomed open boat with high stem. Fitted with mast and oars.—Moorshedabad, Bengal.

50. MODEL. "PURINDA." A long narrow open boat.—Moorshedabad, Bengal.

51. MODEL. "PULWAR." A boat for inland navigation, generally used for the transport of precious goods. It is decked and fitted with cabin, lowering mast, square sail, and oars.—Moorshedabad, Bengal.

52. MODEL. "CHEEP." A long narrow boat decked with bamboo and covered with an awning. It is generally propelled by from 10 to 20 rowers, and is fitted with mast, sail, and paddles.—In common use at Moorshedabad, Bengal.

53. MODEL. "SONAMUKHI" or "TAPWA." A long narrow open boat fitted with mast, paddle, &c. Used for fast travelling.—Dacca, Bengal.

54. MODEL. "NAUKA." A carvel-built boat with decked ends, and decked amidships with open battens.—Bancoorah, Bengal.

55. MODEL. "DONGA." Ferry boat made of two "dugouts" fastened close alongside each other.—Bancoorah, Bengal.

56. MODEL. "BHELA." A raft made of the stems of "*Aeschynomene paludosa.*" Used for crossing rivers and for fishing.—Bancoorah, Bengal.

57. MODEL. Twin ferry boat. Two large flat-bottomed clincher-built boats connected by a framed and planked platform.—Bancoorah, Bengal.

58. MODEL. "LANGADY." Twin ferry boat. Made of two hollowed trunks of Palmyra trees connected at the head by two poles lashed across, and at the stern by a rope.—Mirzapore, Bengal.

59. MODEL. "BOJHINKA." An open boat with "dugout" bottom, and raised sides added.—Sylhet, Bengal.

60. MODEL. "PULWAR." An open boat with rounded covering and raised prow peculiar to the Eastern district.—Sylhet, Bengal.

61. MODEL. "VEWA." Raft made of the stems of plaintain trees secured by pieces of bamboo run through them crosswise.—Jessore, Bengal.

62. MODEL. "KHEYA NAO." Flat-bottomed ferry-boat, with lowering end for embarking and disembarking cattle, carts, &c.—Midnapore, Bengal.

63. MODEL. "ULAK." Boat used for the conveyance of produce. A large clincher-built boat, with the ends decked and the centre generally covered by mat awnings. Fitted with mast, sail, oars, &c.—Bhagulpore, Bengal.

64. MODEL. "HOOLUNG." A merchant's boat. Fitted with wicker-work awning, oars, &c.—Assam.

65. MODEL. "KHÊLE NAO." Rowing boat used by gentlemen in Assam. Fitted with wicker-work cabin, oars, &c.—Assam.

66. MODEL. "DÂK NAO." Mail boat. An open "dugout" with wicker-work awning.—Assam.

67. MODEL. "KHELNAO." A long open pleasure boat, propelled by oars.—Assam.

68. MODEL. Long black boat for river service.—Burmah.

69. MODEL. War boat, gilt, with figures of rowers and others.—Burmah.

70. MODEL. Decked coasting vessel, fitted with three masts, red Chinese lateen sails, and armed with a brass pivot gun.—Burmah.

71. MODEL. "MAAK" or "MARK." A raft made of bamboos and cane.—Chittagong, Burmah.

72. MODEL. "DINGI SHORANGAH." A "dugout" boat converted into a dingi. Fitted with oars, anchor, awning, &c.—Chittagong, Burmah.

73. MODEL. "PUNJAJAB." A Malay rajah's barge. An armed and decked vessel resembling a pirate prahu, and fitted with two masts, boom lugsails made of strips of palm leaves, and paddles.—Singapore.

74. MODEL. "SAMPAN." A fast sailing open boat, used chiefly for passengers. Fitted with three masts, lateen sails, jib, and paddles.—Singapore.

75. MODEL. "KOLEK." An open fishing boat, for sailing or rowing.—Singapore.

76. MODEL. "TAMBANGAN." Passenger boat. An open boat, fitted with one mast, and a peculiar triangular sail, paddles, and a light awning.—Sourabaya, Java.

77. MODEL in ebony. "Dug-out" canoe.—Patna.

78. MODEL. Raft, consisting of two "Dug-outs," connected by cross beams, and a layer of longitudinal beams over all.—Patna.

79. MODEL. Boat paddle, for the use of a chief's wife.—Baram river.

80. PADDLE. "SAY." For the use of a chief's wife.—Baram river.

81. PADDLE. "SAY." For the use of a chief's wife.—Baram river.

82. MODEL. "SAMPAN." An open boat with six paddles.—Johore.

83. MODEL. "KHUNDA." A "dugout" boat used in the shallows.—Goalunda.

84. MODEL. "PRAHU." An armed sailing and rowing vessel, decked. Has two tripod masts, boom, lug-sails, and jib.—? Indian archipelago.

85. MODEL. "BHELA." A fishing raft, with curled-up prow.—Bogra, Southern Philippines.

86. MODEL. "LANUM PRAHU." A large pirate vessel, decked, and fitted with two masts, boom, lug-sails jib, and paddles.—Mindanas, Southern Philippines.

87. MODEL. "GHARNAI BHELA." A fishing raft made of six earthen pots supporting a bamboo framework.—Gyah.

88. MODEL. Rowing and sailing barge, with high stern and raised house.

89. MODEL. Sailing and rowing boat, with mast, sail, and oars.

Note.—The stern of this model is highly carved and ornamented.

90. MODEL. "BATELLO." An Arab sailing vessel, decked and fitted with two masts and lateen sails.

91. MODEL. "BHAULEA." A river boat used on the Ganges.

92. MODEL. Rowing boat.

93. MODEL. Pinnace. Partly decked, and fitted with cabin, one mast, &c.

94. MODEL IN IVORY, "MOHR PUNKEE." Peacock boat. A Hindoo pleasure boat.

95. MODEL. A long shallow open boat.

96. MODEL. A long shallow open boat.

97. MODEL. An open boat with carved prow and stem. Fitted with mat awnings.

98. MODEL. Open boat. (In a glass case.)

99. MODEL. Double boat. (Painted.)

100. MODEL. "BAREE." Cargo boat, fitted with sails, &c.

101. MODEL. Punt.

102. MODEL. Boat with figures and banners.

103. MODEL. Flat boat with rail sides.

104. MODEL. Punt.

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385. COLLECTION OF NATIVE MODELS OF FISHING BOATS FROM THE STRAITS SETTLEMENTS.

Presented by the Commissioners for the Straits Settlements at the International Fisheries Exhibition, South Kensington. 1883.

1. MODEL. Fishing boat. Malay name, "KOLEH PANGAIL." Rigged with sprit sail, fore sail, and spanker.—Straits Settlements.

2. MODEL. Singapore fishing boat. Malay name, "KOLEH PANGAIL."—Straits Settlements.

3. MODEL. Fishing boat. Malay name, "KOLEH PANGAIL." —Straits Settlements.

4. MODEL, rigged. Boat with three felucca sails.—Straits Settlements.

5. MODEL. Malacca fishing boat. "PANGAIL MALACCA." Fitted with mat lug-sail.—Straits Settlements.

6. MODEL. Malacca fishing boat. "PANGAIL MALACCA." Fitted with mast and sail.—Straits Settlements.

7. MODEL. Singapore shrimping boat.—Straits Settlements.

8. MODEL. Selangor Fishing boat. "PRAU KETIAP." Fitted with deck-house, mat sail, &c.—Straits Settlements.

9. MODEL. Selangor fishing boat. "PRAU KOLEH."—Straits Settlements.

10. MODEL. Malacca fishing boat. "PRAHU PÛKAT." A boat from which the pûkat, or seine net, is used.—Straits Settlements.

11. MODEL. "PENGHAMBAT RHUMHU." A small boat used on rivers for catching fish with sharp pointed mouths.—Straits Settlements.

12. MODEL. Selangor fishing boat. "SANPAN PANJANG." Fitted with mast, oars, anchor, &c.—Straits Settlements.

13. MODEL. Selangor fishing boat. "PRAHU KAKAP." Fitted with mast, sail, &c., complete for fishing.—Straits Settlements.

14. MODEL. Johore river fishing boat.—Straits Settlements.

15. MODEL. Johore river fishing boat.—Straits Settlements.

16. MODEL. Selangor Chinese fishing boat.—Straits Settlements.

17. MODEL. Malacca—Chinese boat. Used for the fish trap. Malay name, "SANCHO" or "SANPAN."—Straits Settlements.

18. MODEL. Perak boat, used for fishing in rivers. Malay name "SAGOR."—Straits Settlements.

19. MODEL. Open fishing boat. "PRAU NADIR."—Straits Settlements.

20. MODEL. Fishing boat. Model is in length 2 ft. 9 ins., beam 7 ins., depth 4 ins.—Straits Settlements.

21. MODEL, roughly made. Fishing boat. Model measures 9½ ins. long, beam 2½ ins., depth 1½ ins—Straits Settlements.

22. MODEL. Fishing boat, black hull and cane gunwale. Model measures 23 ins., beam 5 ins., depth 4 ins.—Straits Settlements.

23. MODEL. Fishing boat. "PRAU LINGGI." Model measures 21 ins. length, beam 6 ins., depth 2 ins.—Straits Settlements.

24. MODEL. Fishing boat. Model measures 24 ins. length, beam 5 ins., depth 3½ ins.—Straits Settlements.

25. MODEL. Fishing boat. Model measures 26 ins. length, beam 5 ins., depth 3½ ins.—Straits Settlements.

26. MODEL. Fishing boat. (Broken.) Model measures 21 ins. length, beam 4 ins., depth 3 ins.—Straits Settlements.

27. MODEL. Malay fishing boat. The model represents the boat afloat, and at work, she is moored, and Malays are fishing for gar-pike with kite and shrimp, rod and line.—Straits Settlements.

28. MODEL. Chinese Sanpan Pûkat, seine fishing boat.—Running before the wind. Model made by Mr. W. A. Pickering. Singalese.—Straits Settlements.

Note.—The foregoing two models are under glass. They show the actual working of the two fishing boats and their crews.

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390. COLLECTION OF CHINESE MODELS OF NATIVE FISHING BOATS FROM THE DISTRICTS OF SWATOW, ICHANG, NINGPO, AND TAKOW.

Presented by the Commissioners for China at the International Fisheries Exhibition, South Kensington, 1883.

Note.—Unless specially stated to the contrary, all models are built to scale of $\frac{3}{4}$ in. to 1 ft., and have one mat sail, anchor, oars, &c.

MODELS of FISHING BOATS from the District of Swatow.—China.

1. MODEL. Fishing boats. Ta tsêng.—Swatow.

These boats are 51 ft. long, with 14½ ft. beam, and have flat bottoms,—a peculiarity of nearly all Swatow fishing craft. Two masts—one nearly amidships and the other aft—bear the sails, which are rectangular, and are made of bamboo leaves fastened together with split bamboo. The hull is divided into water-tight compartments, where the fish are stored until the vessel's return to port. The forward compartment is generally used as a fresh-water tank, and the after one for the crew, which generally consists of six men. When there is no wind, recourse is had to yulohs (large sculling oars), to propel the vessel. The anchor in the *ta tsêng*, as well as in all other similar craft, is made of hard-wood. The masts can be unshipped and stowed on deck. On either bow, outside the boat, an eye is painted, which according to the superstition of the country, enables the vessel to find her way, and thus preserves her from mishap.

2. MODEL. Fishing boat.—Swatow.

Dimensions, 50 ft. long, 14½ ft. beam. This boat differs little from the preceding, having nearly the same shape, but not quite so much sheer. It has three masts.

3. MODELS. Two boats with trawl net. Chua tsêng.—Swatow.

These boats are 41 ft. long, 10¾ ft. beam. They have a net hanging between them, and drag it as they move along. They are used between September and April.

4. MODEL. Fishing boat, Li niao, and bamboo raft, Chu 'ai.—Swatow.

A net hangs between them, which is used in the way just described. Employed from March to September.

5. MODEL. Boat for dip net fishing. Ao tsêng.—Swatow.

This boat is 25 ft. long, with 8½ ft. beam. The net is hung from the end of a long arm or lever, which projects like a movable bowsprit over the water. By a simple contrivance it is dipped below or raised above the surface.

6. MODEL. Two boats fastened together for night fishing. T'iao pai.—Swatow.

These boats are 25½ ft. long, with 2¾ ft. beam, and of very light draught. On the outside are boards painted white, 2½ ft. wide, projecting outwards like a shelf, but sloping a little towards the water. Fishermen go out in these boats on bright, clear nights, and as the light of the moon falls on the boards, the fish leap upon or over them into the boat, and are captured. Employed from April to September.

7. MODEL. Fishing boat. Nei wan.—Swatow.

This model is not made to scale. These boats are employed from April till August.

8. MODEL. Fishing boat. Kou tiao ch'uan.—Swatow.

This boat is 32 ft. long, with 10½ ft. beam. It is built in water-tight compartments, for stowing the fish. A mat spread over the top affords shelter to the crew.

9. MODEL. Fishing boat. Niao wang.—Swatow.

This boat is 28 ft. long, with 8 ft. beam. It is built with open compartments. In the after part a small space is covered in for the crew.

10. MODEL. Fishing boat. Tiao ts'ao.—Swatow.

Has a flat bottom, and is generally 36 ft. long, with 11½ ft. beam. The centre of the boat is left open; in the fore part is a tank for water; and the after part is decked over for the crew. Is employed from May to October.

11. MODEL. Fishing boat. Shou yü ch'uan.—Swatow.

Is 28 feet long, with 9 ft. beam, and built like the preceding. Usually employed as a tender to boats of the kind described under No. 1.

12. MODEL. Fishing boat. Ch'en kou.—Swatow.

Length 29 ft., with 10 ft. beam. This boat is entirely open, but a mat spread across the boat affords shelter for the crew. In the after part is a small compartment used for cooking.

13. MODEL. Sampan. Hsiao li niao.—Swatow.

Length, 23 ft., with 8¾ ft. beam. Boats of this kind are generally used as passenger boats; it is only when times are hard, or when large hauls of fish are being made, that they attempt the ardous work of fishing.

14. MODEL. Tic-à-tac. Tan t'a.—Swatow.

This boat is 18 ft. long, with 4 ft. beam, and is employed in the same manner as the preceding; it is propelled, when there is no wind, by one car at the stern.

15. MODEL. Cockle-fishing boat. Hung jou ch'uan.—Swatow.

This boat is 28 ft. long, with 8 ft. beam, and is built in compartments. A net is used for dredging cockles from the bottom. These are stowed in the compartments until the return to port.

16. MODEL. Boat for shell fishing. Po k'o ch'uan.—Swatow.

Length 40 ft., beam 11 ft. Is built like the boat just described. On either side, suspended on outriggers, are large bamboo baskets, in which the fish are washed and sorted before being put into the boat. These boats are propelled by two or more oars (yulohs), and are employed all the year.

17. MODEL. Mandarin boat. Ting shan ch'uan.—Swatow.

Length 34 ft., beam 10½ ft. Employed in cruising about the various fishing grounds for the protection of boats engaged in fishing.

18. MODEL. Cargo junk. Ta hung t'ou yang ch'uan.—Swatow.

These junks are employed in conveying cargo between the various ports on the coast, and some of them can carry as much as 1,000 tons. They are built of soft-wood, and have a flat bottom and a large rudder, which enables them to turn easily, a characteristic of nearly all Chinese craft. The hull is divided into water-tight compartments for stowing the

cargo; across the bow, which is very bluff, is fixed a windlass for raising the anchors. Four masts of hard-wood bear the sails. The two after masts stand on either side of the vessel, and are joined together at the top by three spars placed horizontally. At the break of the poop on the port side is the galley; and on the starboard side, the rice, fish, and various articles of food are washed and prepared for cooking. Abaft these places are the water-tanks. The space underneath the poop is occupied by the lowdah, or sailing master, who looks after the steering and navigation of the vessel. The sterns of these junks are very elaborately carved and painted.

19. MODEL. Cargo junk. Ch'ing t'ou chien ch'uan.—Swatow.

Built of soft-wood. The hull is divided in the same manner as just described (No. 18). This vessel has three masts, which carry sails of coarse matting. In steering, the rudder is sometimes slung to the stern vertically, and sometimes with the post inclined forward. This adaptability of the rudder to different adjustments, according to the depth of water, is a characteristic of a great many Chinese craft.

20. MODEL. Cargo junk. Yüan wei.—Swatow.

Built of soft-wood. The hull is divided into compartments for stowing the cargo. There are two masts, one in the fore part and the other amidships; and in the after part, space is reserved for the crew.

21. MODEL. Cargo junk. Hsi ts'ao.—Swatow.

Boats of this class are generally employed for carrying shells. The bulwarks are not flush with the side, as in most large cargo boats, but are placed a little inboard. The crew usually consists of 10 men.

22. MODEL. Cargo junk. Ta shan fang.—Swatow.

The decks of these boats are nearly flat. They are employed in carrying cargo to and from the various steamers that visit Swatow.

23. MODEL. Cargo boat. Pa chiang t'ing.—Swatow.

The hulls of these boats are divided into compartments, which are usually left uncovered. In wet weather, rain-proof mats are spread over the boat to protect the cargo, which frequently consists of sugar.

24. MODEL. Cargo boat. Ch'ao yang chin ch'uan.—Swatow.

The hulls of these boats are divided into nine compartments, the two after ones being reserved for the crew, which generally consists of 10 men.

25. MODEL. Cargo boat. Ta chu kan ta.—Swatow.

The hulls of these boats are left open, mats being spread across to protect the cargo in wet weather. There is a tank forward for fresh water, and at the stern space is reserved for the crew. When no cargo offers, these boats carry passengers.

26. MODEL. Cargo boat. Wu tu.—Swatow.

These boats are of very light draught. They are divided into eight compartments, and are fitted with one mast only.

27. MODEL. Cargo boat. Chu kan ta.—Swatow.

This boat is like the one described above (No. 25), excepting that it is somewhat smaller.

28. MODEL. Cargo boat. T'u ts'ao.—Swatow.

Boats of this kind are nearly rectangular in shape; they have flat bottoms, and are usually employed in carrying ballast to Foreign vessels.

29. MODEL. Cargo boat. Li niao.—Swatow.

These boats have two masts, with mat sails. The crew sleep on deck, no space below being reserved for them.

30. MODEL. Paper boat. Liu p'êng.—Swatow.

So called on account of the very thin planking with which they are sheathed. The bow raises high out of the water, and amidships stands a large bamboo mat-house, over which a wooden frame is erected, for laying the oars when not in use. The draught of water is very light; and these craft are employed in carrying passengers up the various rivers and creeks with which the country abounds.

31. MODEL. Cargo boat. Ch'ang wei ch'uan.—Swatow.

These boats are divided into compartments, which are left open. They are used for carrying cargo to and from the various Foreign vessels which visit the port.

MODELS of FISHING BOATS from the District of Ichang.—China.

32. MODEL of boat, with cast (or bell) net and otter.—Ichang.

The net is cast first, and then the otter, attached by a cord to the boat, is lowered inside the net—the object being to frighten fish out of holes in rocky or uneven bottoms into the net, which, as soon as lifted, is closed at the bottom by the leaden sinkers, and the fish are thus caught. The fish sought for are of miscellaneous kinds, and the otter requires regular training.

33. MODEL of boat, with dip net and trap attached.—Ichang.

Used like an ordinary dip net, and chiefly in the gorges of the Yangtze. The dip net with trap is lowered, when a slack current allows, for a certain length of time, generally throughout the night; and the fish which enter the net, slip into the trap, and are thus secured.

MODELS of FISHING BOATS from the District of Ningpo.—China.

34. MODEL. Cuttle-fish boat. Mo yü ch'uan, Wu tsei ch'uan.—Ningpo.

The boat is 55¾ ft. long, with 8¼ ft. beam, and has a double keel—a peculiarity of nearly all Chinese sailing craft. Two masts in the fore part of the vessel bear the sails, which are managed by sailing masters, called lowdahs, one stationed in front of the mainmast, the other in the after part of the vessel. The deck consists of movable planks, allowing access to the hold, which is divided into compartments, where the fish are stored until the vessel's return to port. The forward compartment is generally used as a fresh-water tank, and the after compartment as a cooking room. One part of the deck has a wooden roof, and is covered in with mats, and the space thus sheltered serves for the crew at night. The crew of a cuttle-fish boat generally consists of 6 men. The mainsail is divided into two unequal parts connected together with bamboo ropes. To keep the sails from getting rotten, they are dyed with mangrove bark. When there is no wind, the crew have recourse to two or more yulohs (large sculling oars), to propel the vessel. The anchor in the cuttle-fish boat, as well as in all other similar craft, is made of hard-wood. The net hangs over the side. The masts can be unshipped and stowed on deck. On either side of the bow outside the boat an eye is painted, which, according to the superstition of the country, serves to find the vessel's way and preserve her from mishap. Fishing for cuttle-fish is carried on both by day and by night. At night a fire is lighted on deck, by the glare of which the fish are attracted to the surface of the water.

35. MODEL. Ice-carrying boat. Ping hsien ch'uan.—Ningpo.

Larger than the cuttle-fish boat, but differing very little from it in internal arrangements. The hull has two decks and several compartments, where the ice is stored. A wooden roof covers nearly the whole length of the boat, leaving open only the space required for working the sails. The crew's quarters are on deck, under the roof. One compartment at either end is reserved for the kitchen and fresh-water tank.

There are two masts in the fore part of the boat. The rudder has the shape of a hatchet, and is fixed deeper in the water than the keel; by this arrangement the boat can be turned quickly, and the steering is rendered easier than in boats where the rudder is either on a level with the keel or above it. The use of the ice-carrying boat, as its name indicates, is to go out to the fishing boats at sea and bring in their catch of fish packed in ice, which article they carry out with them for the purpose. When outward bound the ice is packed in alternate layers with straw mats, and on the return the mats are replaced by fish. Dimensions, 65½ ft. by 13 ft.

36. MODEL. Boat for night fishing. T'iao yü ch'uan.—Ningpo.

These boats are 29½ ft. long, and 1¼ ft. wide, with a very light draught of water. All along one side of the boat is a board about 1 foot wide, projecting like a shelf, but sloping a little towards the water, and along the other side a net is erected perpendicularly. The board or shelf is painted white. Fishermen go out in these boats on bright clear nights, and, attracted by the light of the moon falling on the board, the fish leap upon or over it into the boat, and are captured. The net prevents their leaping into the water on the further side of the boat.

37. MODEL. Cormorant boat, with cormorants and fisherman. Lu tzŭ ch'uan.—Ningpo.

Fishing with cormorants is carried on in lakes, rivers, and canals, where there is no tide. The boats are very light, 18 ft. long by 2¼ ft. wide, and draw but little water. The birds sit on the rail, and are urged into the water by the boatman, with a pole. Baskets carried in the boat receive the fish. Cormorants usually require to have a hempen cord round the neck to prevent their swallowing the fish.

Many are the ways used in this province [Chêhkiang] for catching fish of all kinds in the rivers, lakes, and canals, but none of them are more curious than the cormorant fishing, which may be seen everywhere about Ningpo. Certain places are noted for the excellence of the birds which are bred and trained there; amongst these we may name Fênghua and Shaohsing.

The most celebrated place, however, is a small town called T'anghsichên, 50 *li* north-west of Hangchow, the people of which are currently believed to possess a secret in cormorant-rearing which gives them special success.

The cormorant's book name is *Lu tzŭ*, and the common name is *Yü ying*, 'fish-hawk,' or *Yü ya*, 'fish crow.'

The females lay yearly from three to nine eggs, in the first and eighth moon. The colour of the eggs is green, but it is much covered with white chalk; their size is that

of duck's eggs. The white inside is slightly green; the eggs are never eaten, on account of their strong flavour.

The eggs of the first season (first moon) are the only ones retained for hatching. Towards the beginning of the second moon they are given to the hens to hatch, as the female cormorant is a careless mother. The young break their shell after a month's incubation. When new born they cannot stand on their legs, and are very sensitive to cold. They are, therefore, taken away from the hen, placed in baskets filled with cotton wool, and kept in a warm place. The eggs of the second season are not used, the weather being too cold; they are given away to children and beggars.

The young birds are at first fed with a mixture, in equal parts, of beancurd and raw eel's flesh cut fine. If eels are not procurable, the flesh of the *Hei yü* (*Ophiocephalus niger*) is used instead, in the form of small pills. At the end of a month the down begins to be covered by the larger feathers, and the quantity of fish-flesh fed to them is increased, while that of beancurd is reduced. A second month elapses, and the young birds, having grown to double their original size, are fit for the market; a male fetches $1 or $2, and a female half as much.

The birds are now fed with young fish thrown to them. When they have attained their full size, a string is tied to one leg, the other end of it being fastened to the bank of a pond or canal. They are then made to go into the water, the trainer whistling a peculiar call and using a bamboo to force them. Small fish are thrown them, upon which they pounce greedily, as they have been kept on short allowance of food. They are now called back by a different whistle-call, and forced to obey by means of the string; as they reach the shore, more fish is given them. This teaching having been gone through daily for a month, another four or five weeks are spent in training the birds from a boat; at the end of this period the string is generally dispensed with. When old and well trained cormorants are made to accompany the young ones the time required in training is reduced one half. Birds not properly trained after all the trouble thus taken are pronounced stupid and not fit for use.

The teaching being completed, the cormorants are fed sparingly every morning with fish. A small ring of hemp is tied round their necks to prevent them from swallowing large fish, and they are taken on board the small punt, called "cormorant boat," to the number of 10 or 12. They are now as docile as dogs, and sit perched on the side of the boat until they are sent into the water by a mere whistle from their master. They dive after fish, and bring their prizes to the boat, firmly held in their hooked beaks. When a fish is too large for one bird, three or more join their forces and capture it together. Sometimes the fishermen signals them to dive by striking the water with a long bamboo. If any cormorant is inclined to be disobedient,

his legs are connected by a short piece of string; this forms a loop, by means of which the bird may at any moment be brought on board *nolens volens* with a long bamboo hook.

After fishing two or three hours, the birds are allowed to come on board and rest. At the end of the day the hempen ring is loosened or removed altogether, and they are either allowed to fish for themselves, or are fed by the hand of their master. Seizing the birds one after another by the upper mandible, the fisherman thrusts into their throats a handful of small fish and a ball of beancurd, as large as his fist, the ingurgitation of which he helps with the other hand by stroking the neck of the bird, who seems to enjoy it, as he promptly returns for a second supply. The entire scene is most ludicrous. At night the birds are brought home and caged. A cormorant holds out for five years, at the end of which time these birds lose their feathers, and soon after die. The females, being weaker than the males, only catch small fish—hence their lower value. Very good birds reach a value of 10 *Tls.* a pair—a well-trained male being worth $6 or $7. The females lay when one year old.

Models of Fishing Vessels from the District of Takow.—China.

38. Model. Catamaran. Chu p'ai. (Anping.) Scale 1 ft. to 10 ft.—Takow.

Catamarans, or bamboo rafts, are of various sizes—from 30 to 35 ft. in length, and 7 to 10 feet in breadth—and consist of from 12 to 14 bamboos. They are the chief means of communication with vessels in the roadstead; no foreign-fashioned boat, when a "bar" is on, could live through the surf.

Catamarans are made of large, partially burnt bamboos of equal size, strongly lashed to each other and to hard-wood cross-pieces, to strengthen them; in the centre a block of wood is fixed, in which the mast is stepped. Each catamaran has three lea-boards, which are of great importance, as without them it would be unable to make way against the high seas or to sail close to the wind. These lee-boards are used, one in the centre, and the other two on the lee side,—being simply inserted between the bamboos, and drawn up when no longer required. Each catamaran is also provided with a rattan or mat screen, to protect the crew from wind and sea,—this screen being made fast in an upright position on the weather side aft. When not used for this purpose, it is placed flat on the fore part of the catamaran, as a sort of platform on which to lay any article which requires to be kept dry. When a catamaran is used for carrying passengers, a tub is securely lashed to the after part of it, and in this the passengers sit. When the catamaran is used for fishing

only, the tub is dispensed with, and baskets in which to put the fish take its place.

The crew consists of three men. In rowing, each man stands facing the direction in which the catamaran is going, and plies two oars, which are pushed from the body, instead of pulled towards it, as in the European manner of rowing When the craft is under sail, one man steers with an oar, which is passed through a rattan becket,—two such beckets being fixed at the stern of each catamaran. The steering is always done through the lee becket. The other two men attend to the sail, &c.

Catamarans rarely capsize in deep water, no matter how heavy the sea is. When they do capsize, it happens generally in crossing the bar inwards, and in the following manner. Two or three high following seas strike the after part of the catamaran, raising it so high that the bow catches the ground or bottom, and then, before the catamaran can rise or recover itself, a heavy sea or a succession of heavy seas follows, forcing the head of the catamaran farther into the bottom, and fairly turning her over,—somewhat obliquely.

In shallow water, instead of anchoring, the catamaran is generally made fast to a pole thrust into the mud ; in deep water an anchor is used.

39. MODEL. Catamaran. Chu p'ai. (Anping.) Scale 1 ft. to 12 ft.—Takow.

Similar to No. 38, but smaller.

40. MODEL. Catamaran. Chu p'ai. (Anping.) Scale 1 ft. to 12 ft.—Takow.

Similar to No. 38, but smaller.

41. MODEL. Catamaran. Chu p'ai. (Anping.) Scale 1 ft. to 12 ft.—Takow.

Similar to No. 38, but smaller.

42. MODEL. Small Catamaran. Chu p'ai. (Anping.) Scale 1 ft. to 12 ft.—Takow.

This kind of catamaran is much smaller than the above, —eight bamboos generally sufficient to make it. It is never taken out to sea, but is used for fishing in harbour, or in rivers and creeks. The crew consists of two men,—one to row, the other to fish. In this description of catamaran, a stone answers the purpose of an anchor.

43. MODEL. Country fishing raft, with net. Ts'ao ti yü p'ai. (Anping.)—Takow.

These rafts consist of from 16 to 20 pieces of bamboo, securely lashed together, and are about 10 ft. in breadth by from 20 to 30 ft. in length. On the centre part of the raft

is a shed, having a frame of bamboo or rattan, which is covered with a coarse kind of straw; this shed is generally occupied by a whole family, and the raft is their only home. The "lifting net" (*chü tsêng*) is fixed at the stern of the raft, and when not in use is kept suspended there. It is spread out to its full extent, and held thus by two long flexible bamboos which cross each other from the corners of the net; at the point of intersection is a bamboo tube, through which a line is passed, and made fast to the top of a sort of bamboo lever. Another lever is made fast at right angles to the first, and lying flat on the raft; and to the latter lever a long line is attached, so that when the net is lowered the second lever rises, and, *vice versâ*, comes down when the net is hauled up. While fishing, the raft is either moored close inshore to a bamboo stuck in the ground, or anchored in the stream. The raft is invariably propelled by poling, and is only used in fresh-water rivers. A species of mullet and other kinds of small fish are caught in this net.

44. MODEL. Fishing junk. K'o tsêng ch'uan. (Anping.) —Takow.

These vessels are strongly built of a species of cedar (*nan mu*) or camphor-wood (sometimes cheaper wood is used), and vary in length from 35 to 42 ft., in breadth from 8 to 12 ft., and in depth of hold from 5 to 6 ft. When fishing, they carry only one mast; when hired as cargo boats, an additional short mast is stepped in the bow.

The crew consists of four men, who live in a sort of cockpit, aft. The fore hatch is always kept closed; but when fishing, the main hatch is open, and the fish caught are thrown into it.

These junks are excellent sea boats, and can "go about" almost within their own length. When "going about" the helmsman calls "look out," and at the same time, by a small windlass, lifts the rudder out of the water, whereupon the junk at once spins round until the wind fills the sail on the other tack, when the rudder is again lowered. The sail is hoisted by a windlass; in a calm, two large oars are used, one at the bow, the other near the stern. These junks generally work in pairs.

45. Twenty-two MODELS of Chinese fishing boats. All are exactly alike in build and rig; each has one mast with mat-sail, and a hold immediately abaft the mast. Most of them have an anchor and a pair of oars. Length of each model is about 18 ins.

Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

Note.—These models were used for the decoration of a trophy of Chinese fishing gear and produce at the International Fisheries Exhibition, South Kensington, 1883.

46. MODEL of Chinese fishing boat, fitted with mast, mat-sail, and pair of oars.
Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

47. MODEL of Chinese fishing boat, fitted with two masts and mat-sails.
Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

48. FULL-SIZE Chinese boat, 21 ft. 6 ins. long and 4 ft. wide.
Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

49. FULL-SIZE Chinese boat, 20 ft. 6 ins. long and 4 ft. wide.
Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

50. FULL-SIZE Chinese boat, 24 ft. long and 3 ft. 3 ins. wide.
Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

51. FULL-SIZE Chinese boat, 17 ft. long and 5 ft. wide.
Presented by the Commissioners for China at the International Fisheries Exhibition. 1883.

Note.—The full-size Chinese boats, Nos. 48 to 51, and the cormorant boat, No. 37, have been withdrawn from Exhibition in the collection of models of ships, boats, and foreign vessels, &c., not of European form.

CLASS II.

Models of Construction.

Sailing Ships and Steam Ships, of Wood, Iron, and Steel. Keels, Timbers, Frames, Beams, Knees, &c. Detail Models and Drawings.

Note on Shipbuilding.

Ships or floating vessels capable of carrying weight over water are found spoken of in history through all ages to the present time from the period of Noah and the construction of the ark.

With regard to the detail of the construction of ships, it appears that prior to 200 years ago no recorded plans or details for shipbuilding exist.

L. Euler, of St. Petersburgh, the mathematician, in 1749, published investigations (Scientia Navalis) of the circumstances in which floating bodies of different forms would be in equilibrium. It was Bouguer, at Paris, in 1746, who, in his "Traité du Navire," first combined theory and practice in the investigations of the principles of the stability of vessels. In 1771, Don George Juan published, at Madrid, a treatise on the construction of ships under the title of "Examen Maritimo." In 1775, Frederick Chapman, mathematician and naval architect to the King of Sweden, wrote a valuable work on shipbuilding, which was translated from the original Swedish first into French by Vial de Clairbois, about 1776, and into English, 1820, by Dr. Inman, Professor and Superintendent of the School of Naval Architecture, attached in 1811 to the Naval College at Portsmouth. In 1791 the Society for the Improvement of Naval Architecture was formed in London. Papers on the stability of ships were also written at this period by Attwood, Dr. Young, and M. Dupin. The present Institution of Naval Architects was founded 1860.

From the lateral action of the waves of the sea against the sides of the hull of a ship, and of the wind against the sails, rigging, and masts, and other numerous causes, is derived the "heel-over" of the vessel, as it is called, to one side or the other, but the ship is prevented from completely overturning by the reaction of the water against the keel and bilge keels, the bottom and sides. Metacentre indicates the most elevated position which the centre of

gravity in a ship can have consistently with the stability. Buoyancy is that quality whereby a ship or any other floating body is enabled to support a certain weight.

When a vessel partly immersed in a fluid moves through that fluid, it experiences a "resistance" in a direction contrary to that of its motion, due to the inertia of the fluid. It also meets with another resistance to its motion through water or fluid, due to the resistance of the particles of the water immediately struck by the vessel and those immediately beyond them for a certain distance compressed on all sides of the vessel and the surrounding fluid compelling the fluid to rise above the general level. The friction of the water along the sides of the vessel is also another source of resistance to her motion through it.

The Admiralty's establishment, 1874–6, at Chelston near Torquay, under Mr. Froude, and a similar undertaking on the part of the Messrs. Denny Brothers at Dumbarton, 1880, contribute in no small degree to the true and practical determination of the resistances of fluids, and their action on the hulls of ships and steamers of all sizes, forms, and proportions.

The measurement of a ship's draught under the conditions of her completed fitting out for sea, and her complete or filled cargo space, is understood as the light water-line, the load water-line. Displacement, register tonnage, gross register tonnage, builder's measurement for tonnage, &c., of all classes of sailing vessels and steam vessels, are expressions of their tonnage measurement.

Rules are laid down and accepted for the regulation of shipbuilding in all its branches and details. These rules for Great Britain are recognised as Lloyd's Registry for Shipping, Rules, and according to their fulfilment by shipbuilders under the supervision of Lloyd's Registry are the ships or steamers completed, "classed," for merit in construction and efficiency in service. The Admiralty also have regulations to be fulfilled if merchant service vessels are to be employed for Imperial purposes. For vessels built in foreign countries and shipping, societies or registries exercise a similar scrutiny over ship construction and efficiency as Lloyd's Registry in Britain.

Some account of early vessels and of shipbuilding will be found in John Charnock's work, 1800–1802. "History of Marine Architecture;" in Cutts' "Middle Ages, 1872;" in Admiral Paris' Historical Work on Ships, published in Paris in 1883. Also in John Fincham's Book on Shipbuilding, 1851, the Master Shipwright at Portmouth Yard;

the late John Scott Russell's publication in 1864–5 on the Modern System of Naval Architecture; S. J. P. Thearle's Naval Architecture, 1874, 1877, 1888; Sir E. J. Reed's Works, 1869, and subsequently; W. Smith's work; J. H. Noble's book on Modern Shipbuilding, 1877; and W. H. White's Naval Architecture, 1877.

The collection of ship models is rich in illustrations of constructive detail. The models presented by the Rev. J. Hardie, relating to detail of wooden ships carried out by Mr. Blake; the models lent by Lloyd's Register of British and Foreign Shipping; by the Nelson Dock Company, Rotherhithe; Messrs. Short Brothers, Sunderland; Messrs. Roydon, Liverpool; Mr. Wimshurst; Mr. John Scott Russell; and the series of models representing modern and recent features of practical shipbuilding made by the Admiralty for the Science and Art Department (1885–1887), may be here cited as examples of value and interest on the subject of ship construction.

Ships as now understood can be classified under the following heads:—

Wooden ships: built of wood entirely.
Composite ships: in which the frames, timbers, and beams, are of iron, whilst the sheathing and planking are of wood.
Iron ships: built of iron entirely.
Steel ships: built of steel entirely.
Composite iron and steel ships: in which the frames, &c., are of iron, the plating being of steel.

It would appear that ships' beams of iron, in lieu of wooden beams, were proposed for use in wooden ships about 1820, again in 1829, and in 1845 by Sir William Fairbairn.

The use of iron in lieu of wood for securing ships wooden beams to wooden ships' sides appears to have been proposed by Roberts about 1808, and by Sir R. Seppings, 1809–1813.

About 1850 iron beams were adopted for wooden ships of war in H.M.'s service.

Diagonal riders of wood, round sterns and round bows, were the proposals of Sir R. Seppings in 1814 for the improvement of war ships.

Diagonal riders of iron for strengthening the sides of wooden ships were the proposal in 1827 of Sir R. Seppings. H.M.S. "CALEDONIA," armour-plated ship, built at Woolwich, 1863, was strengthened in this way. In the

mercantile marine, the half models lent by Messrs. R. Duncan & Co., Port Glasgow, of the sailing ships "JAMES NICOL FLEMING" and "OTAGO," built by them in 1869, show similar plans. The drawings of ship construction, lent by Lloyd's Register of Shipping, together with other drawings and models in the ship model collection, illustrate the system of diagonal iron riders.

The diagonal system of wood planking for ships was devised by Messrs. Johns and Oliver Lang, about 1835–37. A half model of a sailing ship planked diagonally in 1864 according to Lloyd's rules for the method, will be found in the collection.

Composite shipbuilding (iron framing and wooden planking) was carried out on the Thames by Ditchburn, 1844.

Iron shipbuilding was carried out in 1820 by Manby, who built the paddle steamer "AARON MANBY" at Tipton at this date. In 1837 an iron paddle steamer was built by Laird, at Birkenhead, and in 1838 another iron built vessel was launched by Ditchburn on the Thames. At Sunderland the first iron ship was built on the Wear in 1851.

Steel shipbuilding seems to have been fulfilled by Jones, Quiggin, & Co., at Liverpool, by Rennie and by Samuda, on the Thames, about 1857.

Composite steel and iron shipbuilding arose about 1880. H.M.'s troop ship "CLIVE" was thus built by Laird Brothers, at Birkenhead, in 1883.

The "DORIS," a sailing ship, barque rigged, was built in 1887 on the composite principle of iron and steel combined, by A. Stephens and Sons, Dundee. Her frame is of iron, the shell is of steel.

Armour plating a ship of war was begun about 1850. In 1855 H.M.S. "TRUSTY" was completed at Limehouse; followed by the "EREBUS," completed at Glasgow; the "TERROR," completed at Jarrow-on-Tyne; the "ETNA," completed at Millwall. These ships were the first iron-clad vessels in the British Royal Navy of Her Majesty Queen and Empress Victoria.

MODELS OF CONSTRUCTION.

1. MODELS, five in number, of ship construction. Wood and iron. Purchased 1874.

1. Half midship section of a corvette, on ½-in. scale, showing the method of ship's framing, fastening beams to ship's sides, &c. Wood construction.

2. Half midship section of an armour-plated ship of war, on ½-in. scale, showing method of the construction of ship's frame, the armour plating and backing, &c. Iron construction.

3. Model showing the present system of framing armour-plated ships of war in H.M.'s service, with ship's skin plating attached. Scale 1 in. to 1 ft.

4. Half block model, on a scale of ¼ in. to 1 ft., showing the principal lines used in "laying off" the "fore" body of a merchant ship.

5. Half block model, on a scale of ¼ in. to 1 ft., showing the principal lines used in "laying off" the "after" body of a merchant ship.

6. Diagram, showing the lines used in "laying off" the "after" body of a screw frigate. Wood construction.

The foregoing five models and diagram, purchased in 1874, were transferred from Educational Section. 1883.

Note.—The above models and diagram illustrating ship construction, are used for reference in the instruction of students in naval architecture. They are prepared under the direction of the Science and Art Department. Similar models form part of the travelling apparatus for instruction in science, lent by the Department to science schools and classes of this country. A few further explanatory remarks as to what the models are intended to represent may be of service.

1. The model of the half-midship section of the wood ship shows the system now in general use in H.M.'s dockyards of framing with long and short armed floors in alternation with the ordinary floors and first futtocks, formerly called cross-pieces and half-floors. The object of this arrangement is to assist the conversion of the timbers, and to improve the shift of butts; the frames having the long and short armed floors are termed filling frames in contradistinction to the regular frames.

2. The model of the half-midship section of the iron-clad ship shows the longitudinal system of framing, as adopted in H.M.'s ships "AGINCOURT," "MINOTAUR," and "NORTHUMBERLAND," and also the method of forming and combining the several parts of the hull.

3. The small sectional model represents the mode now adopted in H.M.'s service of framing iron-clad ships, more particularly of forming and fitting the frame plates, being a modification of that shown by the larger model. The object of this plan is to economise weight of materials and cost of workmanship, and is termed the bracket system of framing.

4–5. The block models are also intended to aid the students in understanding the principals of the geometry of ship-

building or "laying off;" they show the forms that the several lines assume by the ship, and how she is cut by the different planes.

6. The diagram, as will be seen, represents the after-body as laid off of a screw steamship built of wood. It has not been considered necessary to prepare a similar diagram of the fore-body, as the character of the lines used in "fairing" is nearly identical. *See Fore-body in Fincham's "Laying off."*

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8. MODEL of two half sterns of a first-rate ship of war, wood construction, showing "Blake's" method for the framing of the timber, &c., and gallery. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

9. MODEL of "Blake's" plan for the prevention of water entering a ship in the event of any accident to the screw. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

10. MODEL of "Blake's" plan for connecting beams to ship's side. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

11. MODEL on "Blake's" plan of futtock timbers, fitted with side chock. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

12. MODEL on "Blake's" plan of futtock timber with side scarf. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

13. MODEL on "Blake's" plan of futtock to dispense with angle chock. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

14. MODEL on "Blake's" plan of two floors made good with chocks at the side of keel. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

15. MODEL of floor and first buttock united together on the old plan. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

16. MODEL of common floor timber, chocked at the heel on the side of keel. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

17. MODEL on "Blake's" plan of two bent floor timbers with saw-kerf in middle of moulding side, to assist the bending. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

18. HALF BLOCK MODEL. Stern elevation of a three-deck line-of-battle ship. Wood construction. Starboard side, showing possible disposition of guns so as to obtain a nearly all-round and a right-aft line of fire Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

19. WHOLE MODEL. Stern elevation of a three-deck line-of-battle ship. Wood construction. Starboard side show stern elevation completed. Port side shows disposition of ship's timbers, wales, &c., and emplacement of gun ports for a right-aft and nearly all-round fire. Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

20. HALF BLOCK MODEL. Stern elevation of a three-deck line-of-battle ship. Wood construction. Starboard side, showing wales and plan of vertical timbering. Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

21. HALF BLOCK MODEL. Stern elevation of a three-deck line-of-battle ship. Wood construction. Starboard side, showing wales, side timbering, and proposed stern disposition of timbers, ports, &c. Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

22. WHOLE MODEL of the bow of a frigate. Wood construction.

The upper portion of the model shows the bow of ship completed; the lower part shows disposition and arrangement of timbers.

Starboard side on an old form; port side on improved form of bow.

Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

23. HALF BLOCK MODEL of the starboard bow of a three-deck line-of-battle ship, about 1835–1840. Wood construction, showing possible line of bow fire from four guns.

Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

24. HALF BLOCK MODEL of the port bow of a three-deck line-of-battle ship. Wood construction. About 1840–1850, showing disposition so as to obtain a possible bow line of fire from six guns.

Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

25. MODEL of an upper deck gun port, showing disposition of framing and timbers.

Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

26. FIVE PIECES, Models, illustrating floor timbers for wooden ships.

Proposed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

27. MODEL of the side of a ship of war, wood construction, showing side of lower deck port, and proposed method of re-sheathing an old ship below the water-line.

Proposed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

28. THREE PIECES, Keel Blocks, Models.

Proposed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

29. MODEL. Design for an improved head board for ships of war. Wood construction.
Proposed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.
Presented by Rev. J. Hardie, Falmouth. 1866.

30. EIGHT MODELS, illustrating various methods, old forms, and new proposals, for connecting beams to ships' sides. Wood construction.
Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.
Presented by Rev. J. Hardie, Falmouth. 1866.

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31. MODEL showing interior of a wooden merchant ship.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

32. MODEL showing the framing of the fore body of a wooden merchant ship.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

33. MODEL showing the framing of the after body of a wooden merchant ship.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

34. MODEL of a diagonally framed ship. Thomas Bilbe's system of construction.—Composite.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

35. MODEL of a ship sheathed with diagonal doubling plank. Sheathing according to Lloyd's rules, 1864.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

36. MODEL of Mr. John White's system of constructing composite, iron, and wood vessels.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

37. MODEL of an old ship showing framing, deck, beams, &c., also lower masts and bowsprit in place.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

38. Sectional MODEL of an iron vessel.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

39. DRAWING of a composite vessel showing the iron framework, and the mode of fastening the wood bottom.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

40. DRAWINGS, 20, illustrating Lloyd's rules and regulations for commercial shipbuilding on Mr. J. White's composite, or iron and wood system, and others.
Lent by Lloyd's Register of British and Foreign Shipping, Cornhill. 1876.

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41. The contractor's MODEL used for the construction of the "GREAT EASTERN" steamship. Designed by the late Mr. I. K. Brunel, F.R.S. (1805–1859), showing size and fittings, &c., of the exterior iron plating.
Built by the late J. Scott Russell, F.R.S. (1808–1882). This ship was designed in 1852, laid down in 1853, built 1857.
Lent by the late Mr. John Scott Russell, F.R.S. 1869.

42. The contractor's MODEL used for the construction of the "GREAT EASTERN" steamship, showing size and fittings, &c., of the interior bottom iron plating.
Lent by the late Mr. John Scott Russell, F.R.S. 1869.

Note.—These half block models of the "GREAT EASTERN" are on a scale of $\frac{1}{4}$ inch to 1 foot.

43. MODEL of the construction of the stern of the "GREAT EASTERN" steamship.
Lent by the late Mr. John Scott Russell, F.R.S. 1869.

Note.—The "GREAT EASTERN" steamship, originally called the "LEVIATHAN," designed by the late I. K. Brunel, born 1806, died 1859, is the largest vessel afloat. She is propelled by paddle-wheels as well as a screw propeller.
The length of the "GREAT EASTERN" is 680 ft. extreme, beam 83 ft., depth 58 ft. The ship has five decks, and was originally fitted up to carry 4,000 passengers, or when called on 10,000 troops. Tonnage 23,000 tons. Carries coals and cargo, 18,000 tons. Draught of water (light) 18 ft., draught of water (loaded) 28 ft. The ship had six masts, rigged

partly square and partly fore and aft. She was built, and launched by hydraulic power, broadside on to the river Thames, at Mr. Scott Russell's works, Millwall. The "GREAT EASTERN" is built of iron on Mr. Russell's wave-line principle, has a double bottom, affording ample and efficient space for water ballast, and is divided into compartments by water-tight bulkheads of iron. The paddle-wheels are driven by engines on the oscillating-cylinder system of 1,000 horse-power nominal. Each engine has two cylinders inclined inwards, and driving direct on the paddle shaft. Arrangements are made for disconnecting the engines from the wheels, or from each other. The engines form two separate and distinct double cylinder engines, having each their own air pumps, condensers, starting and stopping gear, &c. The diameter of the cylinders is 74 ins., length of stroke 14 ft., number of strokes per minute 14. Each cylinder is cast in one piece, and weighs 28 tons. The condenser is a casting in one piece weighing 36 tons. The upper frames of the engines are in four castings, each of 13 tons weight. The diameter of the paddle-wheels is 56 ft. They have 30 floats, and in turning round once will advance 60 yards. The paddle engines (patented in 1853) and boilers were constructed by Messrs. J. Scott Russell and Company. The screw propeller is driven by horizontal direct-acting engines on the connecting-rod principle, made by Messrs. James Watt and Company, Birmingham, and are of 1,700 nominal horse-power. The engines have four cylinders, each 84 ins. diameter, and 4 ft. stroke. They drive a screw 24 ft. in diameter, 44 ft. pitch, and weighing 36 tons. The screw shaft is 160 ft. long, and weighs 60 tons. The engines are controlled by Silver's patent marine engine governor, made by Hamilton and Company, Glasgow, 1859.

The boilers of the ship, 10 in number, supplied steam to the paddle-wheel and screw engines at a pressure of 15 to 25 lbs. per square inch.

In 1888 the "GREAT EASTERN" ceased to exist as a steamship.

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44. SERIES of WHOLE and HALF BLOCK MODELS, in wood. 59 in number. Illustrating Theoretical Principles of Ships' Lines.

Lent by the late MR. JOHN SCOTT RUSSELL, F.R.S.

1868.

Note.—These models, on about $\frac{1}{4}$ in. to 1 ft. scale, illustrate the gradual development of Mr. John Scott Russell's wave-line system for ship construction, and exhibit intermediate steps from the square box model (No. 59) to the complete theoretical rendering of the idea in model No. 1.

The different models represent the experimental forms used for instruction and comparison.

The following MODELS, Nos. 3, 5, 8, 12, 13, 14, 17, 18, 20, 21, 22, 24, 34, 35, 36, represent some of the most successful steamers and yachts which have been built upon the wave-line system by Mr. Russell:—

3. Whole Model, on about ¼ in. to 1 ft. scale, of the iron paddle-wheel steamship "BARON OSY." Tons, 400. Designed and built, 1840, by Mr. J. Scott Russell, and run between London and Antwerp as a passenger and cargo vessel up to 1874.

Note.—This "BARON OSY," length about 200 ft., breadth about 26 ft., after 35 years' service as a trader between London and Antwerp was replaced by a new "BARON OSY," built of iron, by Mitchell and Co., Low Walker, Newcastle, 1875, 245 ft. long, 1,100 tons burthen. She has feathering paddle-wheels, and compound engines by Thompson & Co. 300 horse-power, nominal.

5. Whole Model, complete, of a small trading screw steamer.

8. Whole Model, complete, of the Sydney and Melbourne Royal Mail Steam Packet Company's paddle-wheel steamer "PACIFIC." Tons, 1,470. Horse-power, 500. Designed and built by Mr. J. Scott Russell.

12. Whole Model, complete, of a steam screw collier with long hull.

13. Whole Model, complete, of a trading screw steamer.

14. Whole Model, complete, of an iron paddle-wheel trading steamer of the "HALDER" class. Built some 25 years ago.

17. Whole Model, complete, of a steam screw collier lengthened. A similar vessel to the "EAGLE" and "CAROLINE" iron screw colliers. Built some 25 years ago.

18. Whole Model, complete, of a long screw steam collier.

20. Whole Model, complete, of the Prussian man-of-war paddle-wheel steamer "DANTZIG," 12 guns 400 horse-power. Designed and built by Mr. Scott Russell.

21. Whole Model, complete, of the paddle-wheel passenger and trading steamer "ROUEN," running between Newhaven and Dieppe. Owners the London, Brighton, and South Coast Railway Company. See Model No. 11.

22. Whole Model, complete, of a passenger and trading screw steamer, designed and built by Mr. Scott Russell. The engines and boilers are placed aft. The passenger saloon and cabin accommodation is amidships. Further cabin room, right aft.

24. Whole Model, complete, of the iron paddle-wheel steam yacht "WAVE QUEEN." Designed and built some 25 years ago by Mr. J. Scott Russell. This vessel was remarkable for her extreme length, very narrow breadth, and shallow depth, all clearly illustrated by this model. She attained a high rate of speed. Scale of model ¼ in. to 1 ft., representing the vessel's length to have been about 220 feet, and her beam about 15 feet. See Model No 9.

Models of Theoretical Principles.—J. Scott Russell.

1. Model, whole block, illustrating solid of least resistance, with elliptical midship section.

2. Whole Model, ribband model, deck retreating. Starboard side built complete. Port side showing ribband.

4. Theoretical Principles, Block Model, whole, illustrating lines of ships, buttocks, and water-lines.

6. Whole Model of a sailing ship. Starboard side planked and complete. Port side shows timbers and waling. Bow portion, the ribband. Wooden ship construction.

7. Whole Model, ribband model. Deck retreating. Wooden ship construction. Port side shows long ribband. Starboard side unfinished.

9. Practical Shipbuilding, block model of the buttock and water-line of the paddle-wheel steam yacht "WAVE QUEEN." See Model No. 24.

10. Whole Model, ribband model. Wooden ship construction. Starboard side completely finished. Port side, ribband.

11. Practical Shipbuilding, block model of the buttock and water-lines of the paddle-wheel steamer "ROUEN." See Model No. 21.

12. Theoretical Principles. Block Model of ship's lines, buttocks, &c.

15. Block Model. Whole model, showing lines and buttock of a small steam screw yacht.

16. Theoretical Principles. Block Model, whole. Water-line and buttocks.

19. Whole Model of the sailing schooner yacht "AMERICA." Built at New York in 1851. Designed by Mr. Steers, N.Y.

23. Hollow block Model, showing form and water-line of a lengthened steam screw collier.

25. Block Model of the hull and lines of the Prussian gunboats, paddle-wheel steamers, "NIX" and "SALAMANDER," water-line, &c.

See Drawing, page .

26. Block Model, whole, showing water-line and form of paddle-wheel steamers built on the lines and model of the "SCHAFFHAUSEN" steamer.

27. Half block Model. Key model for a yacht or small vessel.

28. Half block Model. Key model for a yacht or small vessel.

29. Half block Model. Key model for a yacht or small vessel.

30. Block Model, whole, illustrating lines of ships, buttocks, &c.

31. Block Model, whole, illustrating lines of ships, buttocks, &c.

32. Block Model, whole, of a flat-bottomed shallow boat, for Indian river navigation. Iron construction.

33. Half block Model. Buttock lines.

34. Whole Model, block, of the yacht "UNDINE." Owned by his Grace the Duke of Sutherland.

35. Whole Model, block, of the sailing yacht "THEMIS."

36. Whole Model, block, of the schooner sailing yacht "TITANIA."

37. Whole Model of a sailing cutter yacht. Form and water-line.

38. Theoretical Principles. Block Model. Water-lines of a ship.

39. Half block Models. The working model used for the construction of iron ships, giving the sizes and thicknesses of the plates, and other working detail.

40. Half block Models. The working model used in the construction of iron ships, giving the sizes and thicknesses of the plates, and other working detail.

41. Block Model, whole, of a shallow-draught river steamer, for Indian river navigation. Iron construction.

42. Sectional Model, H.M.S. "WARRIOR," built 1860, as originally designed by Mr. Scott Russell, showing proposed method of armour plating, &c.

43. Theoretical Principles. Hollow block Model of a ship's hull, showing form and water-line.

44. Theoretical Principles. Hollow block Model of a ship's hull, showing form for least resistance, water-line, &c.

45. Theoretical Principles. Hollow block Model of a ship's hull, showing form and water-line.

46. Theoretical Principles. Hollow block Model of a steamer's hull, showing form and water-line.

47. Theoretical Principles. Hollow block Model of a ship's hull, old form, showing form and water-line.

48. Hollow block Model of the hull and water-line of the Royal Mail screw steamer "VICTORIA "AND ADELAIDE," Australian liner. Designed by Mr. J. Scott Russell.

49. Theoretical Principles. Hollow block Model of a long ship's hull, showing form and water-line.

50. Theoretical Principles. Hollow block Model of the hull of a paddle-wheel steamship with retreating sides for the wheel space.

51. Theoretical Principles. Hollow block Model of a steamship's hull. Lines and form on the wave-line principle.

52. Theoretical Principles. Hollow block Model of a ship's hull, old form.

53. Theoretical Principles. Hollow block Model of a ship's hull on the lines of a Dutch galiot.

54. Theoretical Principles. Hollow block Model of a long ship's hull, showing form and water-line.

55. Theoretical Principles. Hollow block Model, illustrating "wave-line" square sections of a ship's hull.

56. Theoretical Principles. Hollow block Model of a ship's hull, old form.

57. Whole block Model, showing form and water-line of a ship of war, designed by Mr. Scott Russell.

58. Whole block Model, showing form and water-line of a proposed ship of war, designed by Mr. Scott Russell.

59. Theoretical Principles. Hollow block Model. Square block form of a hull and water-line.

The foregoing 59 models, illustrating theoretical and practical principles of ship construction, lent by the late Mr. J. Scott Russell, F.R.S. 1868.

45. DRAWINGS (lithographs). 59 Plates. Illustrating practical shipbuilding.

Lent by the late Mr. John Scott Russell, F.R.S., 1868.

Plate 22. Practical ship construction, iron.
Midship section of an iron ship, showing internal construction and iron bulk-head.

Plate 33. Projections.
Lines. Paddle-wheel steamer. Port view.

Plate 34. Projections.
Lines. Paddle-wheel steamer. Starboard view.

Plate 35. Projections.
Lines. Paddle-wheel steamer. Port view.

Plate 36. Projections.
Lines. Paddle-wheel steamer. Starboard view.

Plate 37. Projections.
Lines. Screw steamer.

Plate 38. Projections.
Lines. Screw steamer. Port view.

Plate 39. Iron shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. Lines.

Plate 40. Iron shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. Enlarged body plan. Lines.

Plate 51. Iron Shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. Iron deck plan.

Plate 57. Lines and structure.
Screw steam yacht, showing longitudinal sections, lines, deck plan, midship section, and sail draft.

Plate 58, 59. Paddle-wheel steamships.
Royal steam yacht.
58, hull complete. Upper deck plan. Sail draft.
59, longitudinal through section. Lower deck plan.

Plate 60, 61. Paddle-wheel steamships.
Extreme shallow-water navigation.
60, longitudinal through section and deck plan.
61, hull complete, and deck plan.

Plate 62. Paddle-wheel steamships.
Channel mail packet. Longitudinal through section. Deck plan.

Plate 64. Screw steamships.
Cargo trader, with water ballast hold. Longitudinal through section. Deck plan.

Plate 66. Screw steamships.
Screw collier. Longitudinal through section. Two deck plans.

Plate 67, 68. Paddle-wheel steamships.
Irish trader.
67, hull complete. Deck plan.
68, longitudinal through section. Deck plan.

Plate 69, 70. Paddle-wheel steamships.
Mediterranean trader and mail ship.
69, longitudinal through section.
70, two deck plans.

Plate 71, 72, 73, 74. Screw steamships.
Baltic trader and Mail packet.
71, longitudinal through section.
72, upper deck plan.
73, under deck plan.
74, hull plan.

Plate 75. Screw steamships.
Auxiliary screw, China clipper. Longitudinal through section. Plan of iron deck.

Plate 83, 84. Ships of war.
Screw gun-boat.
83, hull, sail draft.
84, longitudinal section. Deck plan.

Plate 77, 78, 79. Screw steamships.
Australian passenger trader.
77, longitudinal through section.
78, upper deck plan.
79, passengers' cabins and saloon plan.

Plate 86, 87, 88. Ships of war, iron.
Paddle-wheel gunboat.
86, hull, drawing.
87, longitudinal through section.
88, deck plan.

Plate 94. Iron shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. External profile.

Plate 95. Iron shipbuilding.
The "GREAT EASTERN" steamship, longitudinal through section.

Plate 96. Iron shipbuilding.
The "GREAT EASTERN" steamship. First deck plan.

Plate 97. Iron shipbuilding.
The "GREAT EASTERN" steamship. Second deck plan.

Plate 98. Iron shipbuilding.
The "GREAT EASTERN" steamship. Third deck plan.

Plate 99. Iron shipbuilding.
The "GREAT EASTERN" steamship. Fourth deck plan.

Plate 100. Iron shipbuilding.
The "GREAT EASTERN" steamship. Fifth deck plan.

Plate 101. Iron shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. Cross section through paddle engine room.

Plate 102. Iron shipbuilding.
The "GREAT EASTERN" steamship. Cross section through boiler room; cross section through screw engine room.

Plate 103. Iron shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. Sail drafts, sections.

Plate 104. Iron shipbuilding.
The "GREAT EASTERN" steamship. Sail draft; half plan, upper deck, disposition of boats, cranes, &c.

Plate 105. Iron shipbuilding.
The "GREAT EASTERN" steamship. Built 1857. Launching.

Plate 112. Wave-line principles.
Forms of least resistance.

Plate 113. Wave-line principles.
Pure wave-lines, body plan, profile, water lines, profile of stern on the vertical system, stern water-line, body stern plan, combined stern body plan.

Plate 114. Wave-line principles.
1. Reconciled wave-lines, pure wave line frame, double bow, profile water-lines, body plan.
2. Reconciled stern with pure wave-line form bow, water-lines, body plan.
3. Reconciled bow with reconciled stern, profile, water-lines, body plan.

Plate 115. Wave-line principles.
Compromised wave-lines, bow and stern forms, water-lines, body plans.

Plate 120. Paddle-wheel steamships. Iron.
Pacific royal mail ships.
Lines. Longitudinal through section.

Plate 123, 124. Paddle-wheel steamships. Iron.
Holyhead Royal Irish mail.
123. Longitudinal through section, upper deck plan.
124. Two deck plans, hold plan.

Plate 127. Paddle-wheel steamships. Iron.
French mail Brazilian liners.
Longitudinal through section. Two deck plans.

Plate 133. Ocean passenger and cargo ships.
Screw steamships. Iron.
Longitudinal through section. Two deck plans.

Plate 144. Ships of war. Iron armour ships.
Captain Cowper Coles' cupola ship.
Fig. 1–4. Plans of arrangement for cupolas and deck.
Fig. 5. Elevation, sail draft.
Fig. 6. Midship section, sail draft.

Plate 145. Ships of war. Iron armour.
Captain Cowper Coles' cupola ship. (Gun turrets.)
Figs. 1 and 3. Cross sections of turrets.
Fig. 6. Elevation of turret.
Figs. 2 and 4. Interior plans of turret.
Fig. 7. Exterior plan, turret.

Plate.—Lloyd's Register of British and foreign shipping :—
Illustrations of its rules for building iron ships, 1863; shewing keelsons, side elevation, midship framings, beams, deck plans.

The foregoing 59 plates, illustrating practical shipbuilding, ent by the late Mr. John Scott Russell, F.R.S. 1868.

46. MODEL of the section of a ship's side. Mr. J. Walker. 1867.

47. MODEL of the section of a ship's side, with armour plates attached. Mr. J. Walker. 1867.

48. MODEL of part of the frame of a ship of war, as proposed by Mr. Joseph Tucker.
Presented by Mr. J. S. Tucker. 1865.

49. Comparative MODEL, showing the oval stern, with quarter ports for guns on each deck.
Presented by Mr. J. S. Tucker. 1865.

50. TWO MODELS of midship sections of vessels.
Presented by Mr. J. S. Tucker. 1865.

51. MODEL showing a method of total under-side fastenings for deck planking.
Presented by Mr. J. S. Tucker. 1865.

52. MODEL of the midship section of a design for a four-decked ship of war, the "DUKE OF KENT," to carry 170 guns. Proposed by Mr. Joseph Tucker in 1809, when Master Shipwright of Plymouth Dockyard.
Presented by Mr. J. S. Tucker. 1865.

53. TWO SPECIMENS of patent grooves and metal sheathing for iron ships.
Presented by Mr. T. B. Daft. 1864.

54. SPECIMEN of zinc sheathing for iron vessels. ("Daft's" patent), 1863.
Presented by Mr. T. B. Daft. 1865.

55. TWO MODELS illustrating plan of wood sheathing for iron ships. Model (marked H.N. 2) shows finish to wood sheathing. Proposed by Messrs. Hooper and Nickson, Liverpool.
Lent by Messrs. Hooper and Nickson, Liverpool. 1870.

56. THREE MODELS of the After Parts of the Submerged propeller Ships "ARCHIMEDES," built in 1839, and "NOVELTY," built 1839–40.
Lent by Mr. Henry Wimshurst, the constructor of the original vessels. 1873.

1. Model of the after body of the original experimental vessel, "ARCHIMEDES," built 1839, as prepared for the application of the submerged screw propeller by Mr. H. Wimshurst, Limehouse.

The model has also attached to it a model in wood of the original screw propeller applied to the ship and used on her first voyage in May 1839.

2. Model showing the complete framing and construction of the after body of the second submerged propeller or screw steamship, the "NOVELTY" built by Mr. H. Wimshurst, 1839–40.

This vessel was the first fitted with direct-acting engines to drive screw propeller, and having means for shipping or unshipping the screw.

3. Model of the after body of the "NOVELTY," the second screw steamer, built in 1839–40, showing Mr. H. Wimshurst's altered position for the submerged screw propeller.

The above models lent by Mr. H. Wimshurst. 1873.

57. MODEL. Midship section of a composite vessel experimentally built and classed at Lloyd's for 11 years.

Lent by the Nelson Dock Company, Limited, Rotherhithe. 1876

58. MODEL. Half midship section of a composite vessel experimentally built, and classed at Lloyd's for 15 years.

Lent by the Nelson Dock Company, Limited, Rotherhithe. 1876.

59. MODEL. Half model of an old paddle steamer, built of wood, showing framing and recess for the wheels. About 1840.

Lent by the Nelson Dock Company, Limited, Rotherhithe. 1876.

60. MODEL. After body and stern framing of an old East Indiaman.

Lent by the Nelson Dock Company, Limited, Rotherhithe. 1876.

61. MODEL, midship section of a composite iron ship; showing timbers, keelsons, ribs and beams, diagonal bracing, and outside wood planking.

Lent by Messrs. Short Brothers, Shipbuilders, Sunderland. 1876.

62. MODEL, midship section of an iron composite ship; showing a proposed method for vertical iron plating and wood sheathing.

Lent by Messrs. Short Brothers, Shipbuilders, Sunderland. 1876.

63. MODEL, midship section of composite ship; showing improved form of stringers and other detail of the iron construction.

Lent by Messrs. Short Brothers, Shipbuilders, Sunderland. 1876.

Note.—With this model is another small model showing exterior wood planking and method of fastening it.

64. TWO WHOLE MODELS, illustrating framings in wood of old ships.

Lent by Mr. T. Royden, Liverpool. 1876.

65. BLOCK MODELS showing lines and proportions of the "HIRSCH" ship. Designed by Hermann Hirsch, Craven Street, Strand, 1875.

Lent. 1876.

Note.—The models represent vessels of from 300 to 500 ft. in length, and on this plan a steamship in the China trade, the "PAUNTING," 210 ft. long, and 800 indicated horse-power, has already been built in 1873, by John Elder & Co., Glasgow. The peculiarity of the construction consists chiefly in forming channel ways along the line of keel to secure less rolling propensity and afford efficient water supply to the screw propeller. A similar principle to the Hirsch ship has been designed for screw steamers by Mr. A. Thomson of Liverpool, about 1873.

66. HALF MODEL showing the External Iron Riders of H.M.S. "CALEDONIA," iron-cased frigate, built in 1863 at Woolwich.

Mr. George Turner, late Master Shipwright, Woolwich Dockyard. 1864.

67. THREE WHOLE MODELS, illustrating the "Double-Ended principle" in shipbuilding; and one sectional MODEL of an "after end," fitted with nautilus propellers, patented by the late Mr. Kennedy, 28th October 1863.

Presented by the late Mr. John Kennedy, Whitehaven. 1864.

The largest of these models, which was the first made, dates March 1862, and was placed in the Museum of Patents in September 1862. The last one placed there was made for the drawings prepared for the patent. The novel points consist in the new form of bottom, propellers, rudders, battery, &c. The propellers are the subject of a patent, dated May 1862.

68. HALF MODEL, showing a proposal for Double Bulkheads in iron ships capable of holding water in case of fire; for strength and security to ship and cargo; and

affording a simple means of testing the tightness of the bulkhead itself. Proposed by Dr. John Taylor, M.D., late Professor of Natural Philosophy in the Andersonian University, Glasgow.

Presented by the late Dr. John Taylor, M.D. 1873.

69. MODEL illustrating McCool's designs and methods for Stopping Holes in ship's bottoms by means of galvanized iron plates and screw bars.

Lent by Mr. J. McCool. 1872.

70. WHOLE MODEL of a proposed Screw Steamship of new design by Mr. Archibald Thomson, Liverpool.

The ship has channel ways on each side of the keel, running deep aft, and to nothing forward.

They form a water lead to the screw, which is placed forward well under ship's counter.

Lent by Mr. A. Thompson. 1874.

71. LITHOGRAPH. Longitudinal elevation and cross sections illustrating Mr. Archibald Thomson's proposals for the improved construction of screw steamships.

Lent by Mr. A. Thomson. 1874.

72. MODELS made of hard paraffin for ascertaining the RESISTANCE OF SHIPS by measuring the resistance of their models.

The late Mr. W. Froude, F.R.S. 1876.

The models from 6 to 16 ft. in length are made of hard paraffin. The experimental apparatus employed in working the model includes appliances for designing, moulding, and casting the models, shaping them by automatic machinery, moving them through the water at the required speeds, and automatically recording the leading phenomena of the trial, namely, the speed, the resistance, and the change of level induced by the speed at each end of the model.

The several processes are illustrated by the accompanying series of seven photographs and two specimens, which may be explained as follows:—

No. 1. The Designer.

This consists of a pile of adjustable templates, the thicknesses of which represent the horizontal intervals between the successive water-lines of the intended models shown on a reduced scale. One edge of each template is an elastic steel band held to a wooden base-piece by adjustable ordinates hinged to the band and sliding through mortices in the base-piece fitted with hinged metal clamps. One of these templates (No. 8) set up as for use is sent to aid this explanation.

The photograph shows them in combination, and represents the intended small scale model by a series of water-lines in

steps, which, if either filled up solid and fair to the salient angle of each, or trimmed off fair to the re-entering angle, would constitute the finished form.

No. 2. *a*. The Moulding Box; *b*. The Mould; and *c*. The Core.

Length. Breadth. Depth.

a. A rectangular wooden box 16′ × 2′ 9″ × 1′ 10″.

In this the external form of the full sized model (that is (*b*) the mould) is shaped by help of a series of rough cross sections deduced from the small scale designer, and into the mould is fitted the core (*c*), which constitutes the figure of the inside of the model. *c* is framed on a series of internal cross sections made good to a service and rendered coherent, first by a series of laths nailed to them externally, and, secondly, by a skin of calico drawn tight over the lathed surface, and then coated with plaster-of-paris and clay. Between this "core" and the "mould" there is, of course, a space, equal to the intended thickness of the model, into which space the melted paraffin is run, and there allowed to remain until by cooling it has become solid enough to bear removal.

Nos. 3 and 4, the Shaping machine.

This is what has sometimes been termed in technical phrase a "copying machine." The model, bottom upwards, and adjusted successively to a series of different levels, travels longitudinally between a pair of revolving cutters, which are caused by means of a hand lever to so recede and approach one another, as the model passes, as to cut upon the model the horizontal section or "water-line," correctly appropriate to the level at which the model is set. At the side of the machine, in full view of the operator, there is a vertical board, which carries either a drawing of the intended model, showing the series of water-lines to be cut, or one of the "designer" templates already described. In front of this board is a "tracer," and the board and the tracer severally imitate upon the appropriate scales (the former by longitudinal motion, the latter by vertical motion) the longitudinal motion of the model and the lateral motion of the cutters. Thus the drawing (or template) passing along beneath the tracer is practically a small scale picture of the model travelling past the cutters, and if the tracer be made to follow the correct line on the drawing (or to follow the edge of the template) the revolving cutters will cut the correct water-line on the model.

The model is then finished by hand with spokeshaves and scrapers, an operation which takes a man about three hours.

No. 5. The Hauling Engine.

This is the instrument by which the required motion through the water at definite speed is given to the model. The dynamometric truck to which the model is attached is connected by a wire rope with a winding drum, driven by a

small stationary double-cylinder steam engine. The engine is regulated by an extremely sensitive governor, acting upon a delicate steam throttle valve, on what is known as the "differential" principle, in which the governor rotates at its own appropriate speed, independently of the engine, the steam valve being opened or closed according as the engine is lagging behind the governor or overtaking it.

By adjusting the centrifugal weights of the governor, with a right and left-handed screw, and by differently speeding the belt which connects it with the engine, any required speed may be assigned to the engine between the limits of about 150 and 350 revolutions per minute, and by further changing the gear wheels connecting the engine and winding drum, speeds varying from 60 to 1,200 ft. per minute may be assigned to the dynamometric truck.

Nos. 6 and 7. The Dynamometric Truck, with model under it.

The dynamometric truck runs on a straight and level railway about 200 ft. in length, suspended over a waterway 36 ft. wide and 10 ft. deep. The model floating in the water is as it were "harnessed" to the truck, and travels with it. It is kept from diverging sideways by a knee-jointed frame or "guider" at each end, of such construction as to perfectly prevent the slightest sideways deviation of the model, but in no way to interfere with its rising or falling, or moving in the fore and aft direction with reference to the truck. The towing strain (*i.e.*, the force necessary to make the model accompany the truck in its longitudinal progress) is taken during the experiment by a spiral spring, the extension of which, measuring the towing force, is indicated on a large scale (through the intervention of certain levers) by a pen which makes a line on a recording cylinder covered with a sheet of paper. The recording cylinder is driven by the truck wheels, and thus its circumferential travel indicates distance run; at the same time another pen, jerked at half second intervals by a clock, records time. Other pens actuated by strings led over pulleys, record the change of level of the ends of the model. Thus the diagrams made furnish an exact measure of the speed, and a continuous record of the resistances and of the change of level of the model throughout the experimental run at steady speed. While starting or stopping, the model is controlled by hand levers to prevent the dynamometric spring being over-strained.

No. 8. A "Designer" Template.

This consists of one of the pile of adjustable templates shown in photograph No. 1, and already described.

No. 9. A Segment of a model.

This specimen segment of a model is partly in a finished condition and partly in the condition in which it is left by the shaping machine, Nos. 3 and 4. It thus shows the series

of water-line cuts made by the machine, and a part of the original cast surface remaining between the cuts.

73. Oscillation of ships. TWO MODELS, transverse sections of ships, illustrating the use of the motion of internal water for moderating the disturbing influence of external waves in ships having large natural stability.

From the Admiralty. 1885.

Note.—The following vessels in the Royal Navy have been fitted with these water tanks:

"INFLEXIBLE." Built 1877.
"AJAX." Built 1880.
"AGAMEMNON." Built 1885.
"COLOSSUS." Built 1882.
"EDINBURGH." Built 1882.
"COLLINGWOOD." Built 1882.
"RODNEY." Built 1885.
"HOWE." Built 1885.
"ANSON." Built 1887.
"BENBOW." Built 1886.
"CAMPERDOWN." Built 1885.
"RENOWN." Built 1886–7.
"SANS PAREIL." Built 1887.

74. COLOURED ENGRAVINGS (7), on a scale of $\frac{1}{8}$-in. to 1 ft., showing details of the steamship "GREAT EASTERN."

Transferred from the Patent Museum. 1886.

Note.—The "GREAT EASTERN" steamship was launched 1857 from the yard of Messrs. John Scott Russell & Co., at Millwall. The following views of the "GREAT EASTERN," are given in the engravings:—Side view, longitudinal section, plan of spar deck, plan of middle side decks, plan of second deck, plan of fourth deck, and lower sectional plan.

For other drawings and models of the "Great Eastern" steamship see pages 134, 141–143.

75. HALF MODEL. Trading sailing ship "LIBERTY AND PROPERTY." Built of wood at Whitby, 1752. Tons 249.

Lent by Mr. James Young, West Dock, South Shields. 1883.

See also pages 64, 69, 95, 218.

76. DRAWING on a scale of $\frac{1}{4}$ in. to 1 ft. Sheer plan; Half breadth; and Body plans; of H.M. frigate "ENDYMION," 40 guns. Built 1797.

Presented by H. Y. Powell, Esq. 1886.

Note.—The "ENDYMION" was built from the lines of the French frigate "POMONE," but a few inches wider, making

her 1,277 tons. She was said to have been one of the fastest sailing vessels in the navy during King George III.'s reign. Her dimensions were as follows :—Length on the lower deck 159 ft. $2\frac{3}{8}$ ins., length of keel for tonnage 132 ft. $4\frac{1}{2}$ ins., breadth extreme for tonnage 41 ft. $11\frac{3}{8}$ ins., breadth moulded 41 ft. $3\frac{3}{8}$ ins., depth of hold 12 ft. 4 ins., burthen in tons $1{,}238\frac{87}{94}$, displacement for foreign service 1,695, tons displacement for home service 1,594 tons, midship section area 510 ft.

The "ENDYMION" was rated at 40 guns, but carried 46 guns on occasion. Main-deck 26 24-pr. guns, quarter-deck and forcastle 18 32-pr. carronades, and two 9-pr. guns. Complement of officers and men 320 to 350.

STRUCTURAL MODELS and DIAGRAMS, relating to MODERN and RECENT STRUCTURE and PRINCIPAL ARRANGEMENTS in SHIPS.

Prepared by the Admiralty, 1885–1887, for the Department of Science and Art.

Purchased. 1887.

80. TRANSVERSE SECTIONAL MODEL on 3 in. scale, showing bar keel, and "through" floor with top keelson. Connecting angles, bottom plating, and riveting shown. The model entends for the distance between the first intercostal on port side to first intercostal on starboard side, and only embraces one frame.

Note.—This model shows the work put into the ship's hull at bottom on each side of the keel line ; in the fore and aft direction it embraces only one frame of the ship.

81. TRANSVERSE SECTIONAL MODEL on 3 in. scale, showing side bar keel with a central intercostal or continuous keelson secured to continuous bulb-iron and angles on top of floor. Connecting angles, bottom plating, and rivetting shown.

Extent of model, same as No. 80.

82. TRANSVERSE SECTIONAL MODEL on 3 in. scale, showing flat keel plate with a centre continuous vertical keel, illustrating method largely used in the Mercantile Marine. Connecting angles, bottom plating and riveting shown.

Extent of model the same as No. 80.

83. TRANSVERSE SECTIONAL MODEL, 3 in. scale, showing middle line work of a bracket frame of a double-bottom

war ship. Connecting angles, plating, and riveting shown.

Model extends from a short distance on one side of middle line to a little distance beyond first longitudinal on the other side of middle line.

84. A similar MODEL to No. 83, but for a water-tight frame.

85. MODEL in elevation, 3 in. scale, showing method of securing frames to vertical keel in a war ship.

Length of model embraces three or four frames, and shows a butt of vertical keel and of keel angle, butt straps, connecting angles, and riveting.

86. MODEL in plan, showing, on 3 in. scale, middle line arrangements, butt straps to keel plates and bottom plates. Riveting in edges and butts, &c.

This model shows the plan followed in a large ship, and embraces three or four frames, extending out from middle line beyond the first strake of inside bottom plating.

87. TRANSVERSE SECTIONAL MODEL, 3 in. scale, showing connexion of beam to frame, stringer plate, stringer angles, gutter angles, wood deck, and riveting. A portion of one frame only is shown.

88. MODEL in plan on 3 in. scale, showing stringer plate, its connexions, and riveting, when the stringer is not water-tight.

This model extends over three or four beams.

89. A similar MODEL to No. 88, when stringer is water-tight.

90. SECTIONAL MODEL on 3 in. scale, showing method of forming the top sides with light angle-bar or bar stanchions as supports, showing riveting and connexions, and embracing one frame only.

91. Similar MODEL to No. 90, but showing the frame and side plating carried up.

92. Similar MODEL to No. 90, but showing wood rough-tree stanchions, the sheer strake being continued above the level of the deck and a vertical clamp plate worked parallel to the sheer strake, to take the heels of the stanchions.

93. HALF MIDSHIP SECTION, on 1 in. scale, of one frame of an ordinary merchant ship of iron or steel, showing riveting.

This model shows on a small scale the connexion of several of the models which have already been described.

94. A similar MODEL to No. 93, but for a double-bottom merchant ship.

95. A TRANSVERSE SECTIONAL MODEL, on 1 in. scale, extending from middle line to just above the turn of the bilge, of one intermediate frame of a double-bottom merchant ship, showing riveting.

96. MODEL in elevation on 3 in. scale, showing disposition of butts of outside plating, riveting in edges, butts and frames (including a water-tight frame) in the system with two passing strakes. This model extends over seven frames.

97. A similar MODEL to No. 96, but showing three passing strakes, the riveting not shown.

98. A similar MODEL to No. 97, but showing four passing strakes.

99. Three models.—MODEL in elevation, and TWO transverse sectional MODELS; showing the method of working a stealer in an inside strake of bottom plating, and showing riveting. Scale of Models 3 ins. to 1 foot.

Note.—There are three models actually, in connexion with and illustrating this system for working in a stealer. One of them is a complete elevation; the other two models show sections of the lines marked A. B. and C. D. on the complete elevation model.

100. Three models.—A similar SET OF MODELS to No. 99, but showing stealer in outside strake. In this case two sectional models also will be found exhibited.

Note.—There are three models actually, in connexion with and illustrating this system for working in a stealer, in an outside strake. One of them is the complete elevation; the other two show the sections on the lines marked A. B. and C. D. on the complete elevation model.

101. MODEL of stem of iron war ship on 1-inch scale, showing its form, rabbets for plating, scarphs, connexions with vertical keel and flat keel.

102. MODEL of stern post of iron war ship on 1-inch scale, showing how it is connected to ship, and how the bottom plating is ended.

103. MODEL on 3-inch scale, showing portion of a transverse water-tight bulkhead worked with flush joints and edges, with tee-iron edge strips, butt straps, and vertical angle bar stiffeners, showing disposition of butts and riveting.

104. MODEL on 3-inch scale, showing method of securing a transverse water-tight bulkhead to the ship, supposing she has a double bottom ; showing riveting.

Note.—This model represents the inner bottom of the ship, the method of securing the water-tight bulkhead to it, and the middle line work.

105. A similar MODEL to No. 104, but illustrating the method largely adopted in ordinary merchant ships, with brackets to prevent panting.

106. A SECTIONAL MODEL on 3-inch scale, showing method adopted to secure watertightness in the case of a bulb angle-bar passing through a watertight bulkhead. Riveting is shown.

107. Similar MODEL to No. 106, but with a tee-bar passing through the bulkhead.

108. Similar MODEL to No. 106, but with a box girder passing through the bulkhead.

109. MODEL in plan on 1-inch scale, showing usual disposition of butts in deck plating. Riveting in of edges and butts and beams shown, and a portion of the model has the deck plank and its fastenings shown. This model embraces six or seven beams.

110. Similar MODEL to No. 109, but showing the arrangement of edges and butts and the fastenings when two thicknesses of deck plating are worked. No deck plank shown.

111. Similar MODEL to No. 110, but with three thicknesses of plating worked.

111A. SECTIONAL MODEL on 3-inch scale, showing usual method of securing wood deck to iron beams when no deck plating is worked.

112. Similar MODEL to No. 111, but showing the arrangement when the flange of the beam is not wide enough to take the butt fastenings.

113. MODEL on 3-in. scale, showing a "tabled" scarph.

114. MODEL on 3-in. scale, showing a "hook" scarph.

115. A TRANSVERSE SECTIONAL MODEL on 3-in. scale, showing intercostal keelson, flat keel plate, frame, angles, and outside planking of a composite ship of war. Riveting and fastenings are shown. This model embraces one frame only, and extends from bilge keelson on one side to bilge keelson on the other side.

116. MODEL in elevation on 3-in. scale, showing middle line work, viz., intercostal keelson, angles, frames, &c. with riveting, embracing three or four frames of a composite war ship.

117. A TRANSVERSE SECTIONAL MODEL, on 3-in. scale, showing the method of working and securing stringers and stringer angles in composite war ships.

118. A MODEL on 1-in. scale. Elevation, showing disposition of edges and butts in outside planking of two thicknesses in a composite ship, showing the fastenings.

119. A TRANSVERSE SECTIONAL MODEL on 3-in. scale, showing the fastening in inner and in outer thickness of planking of a composite ship.

120. A LONGITUDINAL SECTIONAL MODEL on 3-in. scale, showing how the scarph of inner thickness of planking is formed, and fastened, in a composite ship.

121. A MODEL in elevation, showing on an inch scale how the fastenings are disposed in the bottom planking of an iron ship sheathed with one thickness of wood.

121A. MODEL in elevation, on a 3-in. scale, showing details of the fastenings illustrated in No. 121.

122. A similar MODEL to No. 121 on a scale of 1-in. to 1 ft., but showing the arrangement when two thicknesses of planking are worked.

122A. MODEL in elevation, on a 3-in. scale, showing details of the fastenings illustrated in No. 122.

123. A MODEL on 3-in. scale, showing the method of framing a hatchway of wood, and securing it to iron beams.

124. MODEL on 3-in. to 1 ft. scale, showing the method of framing a hatchway of iron or steel, and securing it to iron beams.

125. A MODEL on 3-in. scale, showing the usual method of constructing iron and steel masts, showing fittings at the head.

126. MODEL in full, on 1-in. scale, showing a riding bitt and its fittings, and the securities to beams.

127. MODEL in full, on 1-in. scale, of a cathead and its fittings, and showing an anchor in its letting-go position.

128. Six outline DIAGRAMS on $\frac{1}{4}$ in. to 1 ft. scale, showing a ship efficiently subdivided by watertight bulkheads.

(1.) In the intact condition at ordinary load-draft with the main deck watertight.

(2.) With the foremost compartment bilged and the main deck watertight.

(3.) With the two foremost compartments bilged and the main deck watertight.

(4.) With the two foremost compartments bilged, but with the main deck *not* watertight.

(5.) With a large central compartment bilged, the remaining compartments being intact, and the main deck watertight.

(6.) With one of the after compartments bilged, the remaining compartments being intact, and the main deck watertight.

129. Three outline DIAGRAMS on $\frac{1}{4}$ in. to 1 ft. scale, in elevation; showing the same ship as in No. 128, but so badly divided by watertight bulkheads that she will be in certain cases of injury worse off, from a stability point of view, than if she were without any bulkheads at all.

Note.—(1.) Ship inefficiently subdivided by water-tight bulkheads. Intact condition at ordinary load-draft.

(2.) Ship inefficiently subdivided by water-tight bulkheads. Hold open to the sea. The water being confined to the damaged end of the ship by the bulkheads, produces a great change of trim, and the end of the ship is rapidly submerged.

(3.) Ship not subdivided by water-tight bulkheads, but damaged as in No. 2, and going down, though much more slowly than in No. 2. Condition is shown at same interval after collision as in No. 2.

The water being unconfined by bulkheads sinks the ship on an even keel, and, as the ends of the ship are not submerged, she will float until the whole of the freeboard is destroyed.

130. OUTLINE DIAGRAMS in section and elevation on ¼-in. scale, illustrating—

(*a.*) Two decked ships.
(*b.*) Three decked ships.
(*c.*) Spar decked and anchor decked ships.
(*d.*) Awning decked ships.
(*e.*) Well decked and raised quarter decked ships.
(*f.*) Partial shade decked ships.
(*g.*) Shelter decked ships.

Note.—There are seven outline diagrams on ¼ in. to 1 ft. scale, illustrating various kinds of decks, as follows :—

(*a.*) A two-decked ship, of not less than 15 ft. depth of hold to the main deck, with two complete decks laid and caulked. Full scantlings to upper deck.

(*b.*) A three-decked ship of not less than 15 ft. depth of hold to the main deck, with three complete decks laid and caulked.

(*c.*) A spar-decked and anchor-decked ship.

Note.—These are vessels of lighter construction than two or three decked ships. They must have three tiers of beams, and not less than 15 ft. depth of hold to the main deck. No erections allowed on spar deck except such as are necessary to navigation. Scantlings as in two decked ships.

(*d.*) An awning-decked ship.

Note.—These vessels have a comparatively light superstructure fore and aft on the main or upper deck proper, in which passengers, cattle, or cargo light in nature or limited in quantity may be carried.

The scantlings regulated by dimensions under main deck, as in one or two decked ships, but exclusive of the awning deck. Erections as for spar-decked ships.

(*e.*) A well-decked and raised quarter-decked ship.

Note.—In some cases raised quarter-decks are such a height as to be continuous with bridge and poop decks.

(*f.*) A partial shade-decked ship. The main deck is the upper deck proper.

(*g.*) A shelter-decked ship.

Note.—See description of awning-decked ships (*d.*).

All erections in shelter-decked, awning-decked, and spar-decked classes are approved by Lloyd's for classing purposes and are considered in fixing the load line mark or disc for safety.

131. MODEL. Half-midship section on ½-inch scale of "BELLEROPHON," showing frames, beams, plating, pillaring, &c., &c. It embraces five frames, the first showing a

bracket frame, the last a watertight frame with a watertight bulkhead.

Note.—There is already in the collection a similar model of "AGINCOURT," and the model shows the great stride in ironclad shipbuilding made by Mr., now Sir E., Reed, in economising weight of materials, cost of workmanship, &c. H.M.S. "BELLEROPHON" was built in 1865 at Chatham. The "AGINCOURT" was built in 1869–70.

132. A similar MODEL to No. 131, of one of the latest armour-clad ships of the Royal Navy, say of the "COLLINGWOOD" class 1882. (There are six ships at present, 1886–1888, under construction of this class.)

Note.—H.M.S. "COLLINGWOOD" was built at Pembroke in 1882. She is one of H.M.'s ships known as the Admiral class of modern war ships, by reason of the vessels, all of similar construction and type, being named after British admirals, *e.g.*, "CAMPERDOWN," "RODNEY," "BENBOW," "HOWE," "ANSON," and so on.

133. MODEL. One frame on ½-inch scale, showing the construction before and abaft the citadel of the ship represented by No. 132.

134. A similar MODEL to No. 131, but showing the double-bottom system which has recently been extensively adopted in building ships for the mercantile marine.

Note.—This model would illustrate that the system is similar in principle to, but different in detail from, that followed in Imperial armoured ships. Messrs. Denny, of Dumbarton, and others, have built a number of merchant ships on the double bottomed principle. (The model is not yet added to the Collection.)

135. A MODEL in elevation, ½-inch scale, showing the foremost frames, stem, keel, plating, stringers, &c., with their connexions, of a merchant ship of iron or steel.

Note.—Model No. 137 shows the same detail of work, as carried out in the construction of armour-clad ram ships in Her Majesty's service.

136. A similar MODEL to No. 135, but showing the arrangements at the stern.

137. MODEL in elevation, ½-inch scale, showing the foremost frames, stem, keel, plating, stringers, &c., with their connexions, as carried out in iron or steel built armour clad ram ships in Her Majesty's Navy. A similar model to No. 135, representing the same details in a merchant ship.

138. A similar MODEL to No. 135, but for a composite war ship.

Note.—The model represents the detail of ship construction, illustrated in Nos. 135 and 137, but applied to a ship of war built on the composite system, iron and wood construction.

139. MODEL. Half midship section, on a ½-inch scale, of a mercantile composite ship, showing framing, stringers, beams, external riders, bottom planking, &c. It embraces four or five frames.

Note.—This type of construction is not now continued, but there are many merchant ships built on it still afloat and doing good work. The construction represents an era in shipbuilding. Messrs. R. Steel & Co., Greenock, and W. H. Potter & Son, Liverpool, have built vessels largely on the system illustrated. (The model is not yet added to the Collection.)

140. MODEL similar to No. 139, but showing the system adopted in Ordinary Composite War Vessels.

141. MODEL similar to No. 140, but showing the Latest type of Composite War Ship with under-water protective deck and improved framing.

142. Half midship SECTION on ½-inch scale of an iron-sheathed unarmoured ship of the Royal Navy, showing the combination of the deep intercostal frame and the shallow continuous frame (intermediate). This model shows four frames with all the connexions, riveting, &c.

143. A whole block MODEL, $\frac{3}{16}$-inch scale, made of tin or sheet iron, fitted with efficient watertight bulkheads, the decks formed of glass. The model laden with small wood blocks to represent cargo. Small circular holes, representing a small leak, say 1 square foot in area, are bored below the water line, one in each compartment on each side of the model, and plugs of soft wood made to fit the holes.

Note.—The model when floated can be manipulated so as to show the efficacy of proper watertight bulkheads in keeping the ship above water till the very last extremity arises.

144. AN exactly similar MODEL to No. 143, but fitted with inefficient watertight bulkheads.

Note.—Nos. 143 and 144 forms a valuable addition to the collection.

The models can be placed intact, side by side, in a tank of water, the behaviour of the models indicating exactly what would take place in the ships they represent. They can be

watched as the pegs in similar positions in the two models are withdrawn, first in one compartment, then in another. The glass decks enable the passage of water into the models to be seen.

145. A MODEL on 3-inch scale, showing the construction and fittings of a large hinged watertight door, for communication through the watertight bulkheads in modern ships of war in Her Majesty's Service.

Note.—Through these doors access is gained to the various compartments of the ship without going up and down hatchways and over upper decks. The doors are controlled under very stringent regulations.

146. A MODEL on 3-inch scale showing a watertight scuttle to a watertight flat.

Note.—The model represents the method carried out in modern ships of war in Her Majesty's Service.

147. Two DIAGRAMS, on a scale of ¼ inch to 1 foot. The principal ventilating arrangements in a large armour-clad of the central citadel type in the Royal Navy.

148. Two DIAGRAMS, on a scale of ¼ inch to 1 foot. The main and auxiliary drainage arrangements in a modern armour-clad ship of Her Majesty's Navy.

149. Four DIAGRAMS on ¼-inch scale, illustrating systems of steering arrangements in recent large ships of war, in Her Majesty's Service:—

(*a.*) Details of steering arrangements for a large war ship.

(*b.*) Details of steering arrangements for a large war ship.

(*c.*) Outline plan of steering arrangements for an armour clad ship.

(*d.*) Outline plan of steering arrangements for an armour clad ship.

CLASS III.

Marine Steam Engines and Boilers.

Note on Marine Boilers.

At the present time two descriptions of boilers for marine purposes are in general use.

1. The multitubular boiler, in the interior of which are arranged a quantity of small tubes fixed in a horizontal direction through which the products of combustion from the fires are made to pass before reaching the up-take or chimney, whilst the water in the boiler surrounds them in mass. These boilers have several furnaces to each boiler which are arranged to be fired sometimes at one end of the boiler only, sometimes at both ends, and sometimes laterally, according as the available space on ship-board will best allow.

Vertical or upright boilers known as "Hay-stack" boilers on the multitubular system are of this group also. They were introduced by D. Napier, of Millwall, about 1840, and are of frequent application still. Marine steam boilers are also known under other titles indicating their type; *e.g.*, Admiralty pattern boilers, steam super-heating boilers, locomotive engine boilers, and so on.

2. Water-tube boilers, in which iron tubes or pipes are fixed in an inclined or other position and through them the water in the boiler circulates. The heat and products of combustion of the furnaces in these boilers are made to travel completely amongst and round the water tubes, before reaching the up-take or chimney, by an arrangement in some cases of iron plates fixed amongst them, known as "Baffle-plates," or by the arrangement and disposition or the water-tubes themselves. In November 1888 Messrs. J. I. Thornycroft, Chiswick, introduced and fitted into a swift torpedo boat for India, built by them, a new form of marine steam generator or boiler on the water-tube system, working at a high steam pressure exceeding 200 lbs. per square inch. In these boilers steam is raised in 15 minutes after fire-lighting, and trouble from priming is said to be obliterated. Fresh water is used.

Some account of the recent plans known as "Forced Draught," carried out in marine steam boilers for artificially urging the fires, proposed by Mr. W. A. Lyttle in 1866, will be found in the note on "Blowing Machines." *See pages* 168, 172, 173, 213.

3. To the foregoing classes of marine steam boilers may be noted as specialties the Herrescheff steam generator for very high pressure (400 to 500 lbs. per square inch), fitted by Loftus Perkins in the screw steam yacht "Anthracite," in 1880, 70 gross register tons. Also Rowan's high-pressure water-

tube steam boilers fitted some time back in the ferry steamers "PROPONTIS," and others, at Liverpool.

4. In May 1888 a novel marine steam boiler was introduced by Messrs. Yarrow & Co., Isle of Dogs, Poplar, E. The invention marks a distinct feature in marine engineering, adapted to driving the ordinary small engines of steam pleasure boats and steam launches. The boiler is practically a spirit vaporizer. Petroleum oil, naphtha, spirits of wine, any spirit in short, supplies the place in the boiler of the usual water for generating steam. The boiler is also heated by petroleum oil consumed in spray form in the boiler's furnace specially arranged for the purpose. In five minutes steam can be raised from the liquid spirit in the boiler to a working pressure of 50 or 60 lbs. per square inch.

The spirit steam having driven the engine or engines, is condensed into liquid again by passing through a pipe (or pipes) of copper, fixed under the boat's bottom outside. The pipe is of course thus immersed in ever changing water, and forms a true surface condenser. The condensed spirit finds its way into a tank or reservoir fitted in the stern of the boat or launch, and thence it flows back to the boiler feed-pump on the engine, to be again converted in the boiler into steam. The oil or spirit is consequently vaporised into steam over and over. The actual waste or loss in working, said to be about one quart per diem, is made up as required by fresh spirit served to the feed pump. The machinery is known as "Yarrow's spirit motor."

Similar machinery of American construction, using naphtha, has also been brought to England and applied to the screw propulsion of pleasure skiffs, by Mr. Rowland Ward, 166, Piccadilly.

A third steam motor, using petroleum oil fuel appeared about the same time from America, known as "Shipman's "Motor," introduced by Messrs. J. C. Rollins & Co., Old Swan Wharf, E.C.

The pressure of steam in marine boilers above atmospheric pressure has been gradually increased from the 7 to 12 lbs. per square inch considered sufficient by Watt (1736–1819) until, owing to improved design and construction, and the use of steel in lieu of iron as material, they now work at a pressure of 150, 180, and even 200 lbs. per square inch.

CLASS III.

Marine Steam Boilers.

MAIN STEAM BOILERS FOR STEAMSHIPS.

1. MODEL, in wood, made in parts to take to pieces, and show interior disposition. Marine multi-flue steam boiler, Hawthorn's Patent 1868. Designed for high-pressure

working, with several new and special features. The boiler is arranged with high level furnaces, interior water tubes, and high steam room.

Lent by Messrs. R. and W. Hawthorn, Newcastle. 1869.

Note.—A set, consisting of two of these steam boilers, was fitted into the iron screw steamship "MERCURY," 120 horse-power, in 1869. Each boiler was 11 ft. long, 9 ft. wide, and 11 ft. 3 ins. high. The boilers have two furnaces each, 2 ft. 6 ins. wide, 3 ft. 6 ins. high, with grate bars 5 ft. long. In each boiler are flues, respectively 2 ft. 6 ins. wide by 3 ft. 6 ins. high. 2 ft. 6 ins. diameter, 1·92 ft. diameter: leading into a dry uptake in front of boiler. The flues and flame chambers are strengthened by water tubes 8 ins. in diameter, which increase the heating surface and promote the water circulation. The furnaces are placed in the centre of the boilers, the water level being 8 ins. above their crowns. The flues lead downwards, the last series being close to the bottom of the boilers. The total internal heating surface in both boilers is 1,320 sq. ft., the grate bar surface 42·2 sq. ft., the working pressure of steam 45 lbs. per square inch. The weight of the boilers, without mountings, 25½ tons. Filled for work, the weight of water is 17¾ tons.

2. DRAWING, coloured. A multi-flue marine boiler for high-pressure, by Messrs. R. and W. Hawthorn, 1868. Scale ½ in. to 1 ft.

Lent by Messrs. R. and W. Hawthorn, Newcastle-on-Tyne. 1869.

Note.—The drawing shows a front view and cross section of the boiler. Longtitudinal through sections and cross sections. A sectional plan.

3. WATER-COLOUR DRAWING. Midship section of the "GREAT EASTERN" steamship. Showing construction and emplacement of the boilers, feed pumps, and steam pipes. Scale, ¼ in. to 1 ft.

Lent by the late Mr. John Scott Russell, F.R.S. 1868.

4. SECTIONAL MODEL, in brass, showing the tubular arrangement, water space, and circulation of Richardson's Vertical High-pressure Steam Boiler.

Lent by the makers, Messrs. Robey & Co., Lincoln. 1874.

5. DRAWING. Richardson's Vertical High-pressure Steam Boiler. Robey & Co., makers.

Lent by Messrs. Robey & Co., Lincoln. 1874.

Note.—The drawing shows a sectional elevation indicating the water circulation and the direction of the fire and products of combustion. Also a sectional plan of the boiler.

6. DRAWING of a tubular upright steam boiler called the "Nozzle boiler," designed and made by the Reading Ironworks Co., Limited, Reading.

The Reading Ironworks Co., Limited. 1874.

7. MODEL of a set of High-pressure marine tubular steam boilers. Designed for the continuous use of fresh water.

Lent by Mr. William Gray, Dawlish. 1874.

Note.—These boilers possess the following arrangements:—They are fired from each end, the furnaces having special air flues designed to assist in the combustion and the consumption of smoke. They are multi-tube boilers, having steam superheaters, and over-all large tanks to contain fresh water, which supply the boilers with heated feed water. The working pressure is 100 lbs. per square inch.

8. DRAWING. Section of Gray's High-pressure marine steam boilers, showing arrangement of the tubes, steam superheater, water heater, and flues. Scale ½ in. to 1 ft.

Lent by Mr. W. Gray, Dawlish. 1874.

9. DRAWING, on a ¾ in. to 1 ft. scale. Improved marine water-tube steam boiler, for high pressure. Designed by Messrs. J. and F. Howard. Made by the Barrow Shipbuilding Co., Barrow-in-Furness.

Lent by Messrs. J. and F. Howard, Bedford. 1874.

Note.—The drawing shows a front view of the boiler, side elevation, longitudinal through section; and a section through tube plates showing method of coning joints, on a quarter full-size scale.

10. DRAWING of Messenger's High pressure Vertical Water-tube Boiler. For steam yachts and launches. Designed by Mr. Thomas Messenger about 1869.

Messrs. A. Verey & Co., Dover. 1875.

11. DRAWING, showing part elevation, section, and plan of the tubular Boilers of the paddle-wheel steam yacht "GALATEA," 200 nominal horse-power. Belonging to the Trinity House Corporation.

Lent by W. Willis. 1876.

Note.—The boilers of the "GALATEA," as well as the ship and her engines, were constructed by Messrs. Caird & Co., Greenock, in 1867. They have a heating surface of 5,308 sq. ft. The fire-grate surface 186 sq. ft. Water space 1,592 cub. ft. Steam space 752 cub. ft. The drawing is on a scale of 1 in. to 1 ft., and is photographed

and printed from the original, by Willis' Patent Aniline Process.

12. ILLUSTRATIONS (full size). The connexions for the water-tubes of marine steam water-tube boilers.

Mr. J. F. Flannery. 1876.

Note.—The water tube connexions exhibited (on the systems known as Root's Patent, Howard's Patent, and the ordinary form), for the joints of the tubes of this class of marine boiler are full working size, and show the means employed for securing efficient circulation of the water throughout the tubes.

13. DRAWINGS. Marine steam boilers for lecture purposes. By Mr. J. F. Flannery, C.E.

Mr. Flannery, 9 Fenchurch Street, E.C. 1876.

Note.—These drawings relate exclusively to boilers for steamships, known as "water-tube boilers." They represent the systems of Messrs. Howard, Root, and Wigzell, for these boilers; and in various forms (as shown by the drawings), they have been fitted and worked in the steamships "BIRKENHEAD," "MONTANA," "PROPONTIS," and steam flat "GERTRUDE," all of Liverpool. Figure 1 of these drawings represents a water-tube boiler of the ordinary type.

14. DRAWINGS, showing elevations, plans, and sections, of Dickinson's and Mace's Multitubular Marine and Land Steam Boilers, 1876. Constructed by J. Dickinson, Engineer, Sunderland.

Lent by Mr. Dickinson. 1876.

15. DIAGRAMS. Coloured drawings for lecture purposes. Marine steam water-tube boilers.

1. Rowan's Boiler, with forced combustion arrangement. (In two sheets.)
2. Boiler of steamship "BELLEVILLE."
3. Watt's Boiler. (In two sheets.)
4. Howard's Boiler.
5. Furnace for marine boiler.

Mr. F. J. Rowan, Glasgow. 1878.

16. MODELS. Illustrating Samson Fox's Corrugated Iron Boiler Tubes for Flues, and their application to land and marine steam boilers.

Lent by Mr. Samson Fox, Leeds Forge, Wortley Leeds. 1879.

Note.—These corrugated iron fire tubes or flues for steam boilers, together with powerful rolling mills for corrugating

the plates for them, were designed and carried out, 1876–7, by Mr. Samson Fox, of the Leeds Forge Company, New Wortley. The corrugated tubes have been tested to the severe pressure of 1,000 lbs. per square inch.

17. SECTIONAL MODEL. Model in copper of a multi-tubular marine steam boiler, with Samson Fox's Patent Corrugated Furnace Flues, and Hepburn's Patent Shell Expansion Ring.

Lent by Mr. Samson Fox, Leeds Forge, Wortley, Leeds. 1879.

18. WORKING MODEL of Mr. Samson Fox's Rolling Mill for corrugating on his system the iron plates for boiler furnaces and fire flues.

Mr. Samson Fox, Leeds Forge, Wortley, Leeds. 1879.

Note.—The model of Mr. Samson Fox's Rolling Mill for corrugating rolled iron or steel plates for boiler flues represents a heavy machine set up at the Leeds Forge Company's Works.

19. DIAGRAMS, coloured, illustrating Flannery's Blast Furnaces for steam boilers. Longitudinal through section. Sectional drawings of details.

Mr. J. F. Flannery, 9, Fenchurch Street, E.C. 1880.

20. SECTIONAL MODEL on ¼ scale. Cochran's High-pressure Tubular Upright Boiler.

Lent by Messrs. Cochran & Co., Birkenhead. 1881.

Note.—The model is constructed of iron, and follows in its detail the actual construction of a real working boiler on Cochran's system. The plan of fire-box and grate, of the tubes, flues, and water space, are clearly indicated.

21. SECTIONAL MODEL. Rowan and Horton's Upright Water-tube Marine Boiler for high pressure, 150 lbs. per square inch. Scale ½ in. to 1 ft.

Lent by Mr. F. J. Rowan, Glasgow. 1881.

Note.—Model represents the boilers fitted in steamships "HACO," and "PROPONTIS," 1874. With it are exhibited sectional pieces of the actual water tubes, showing results of incrustation and corrosion. In 1858 boilers working at 150 lbs. per square inch were fitted to the steamer "THETIS."

Rowan and Horton's boilers have also been tried in steamships "MONTANA," "BELLEVILLE," and others.

22. MODEL. Midgley's Vertical Steam Tubular Boiler.

Mr. D. Midgley, Stanningley. 1882.

Note.—The boiler has, surrounding its lower part, a chamber, forming a product of combustion mixing and consuming space.

23. MODEL. Sectional model of an iron funnel or smoke stack for land and marine boilers; illustrating Wery's system for increasing draught by means of differential air ways inserted around the funnel in screw form, inside a jacket or casing.

Livet's Improved Boiler Co., London. 1882.

24. TWO COLOURED DRAWINGS, on a scale of 1 in. to 1 ft., showing the boilers and engines of the steamship "BATOUM." Built of steel, 1882, for the Russian Steam Navigation and Trading Company, Odessa, by G. Mitchell & Co., Low Walker, Newcastle.

The Wallsend Slipway and Engineering Company, Limited, Newcastle-on-Tyne. 1882.

Note.—The steamship "BATOUM" is 310 ft. long between perpendiculars, 37 ft. beam, and 20 ft. 10 ins. draught. Speed 12 knots. The engines are compound, having two cylinders, and are supplied with steam by steel boilers working at 80 lbs. per square inch.

25. TWO PHOTOGRAPHS. Inverted compound direct-acting surface-condensing screw engines, fitted to steamships "SHEIK," 1880, "CORRIENTES," 1881, and "MAHA VAJIRUNHIS," 1881, built of iron by C. Mitchell & Co., Low Walker, Newcastle.

The Wallsend Slipway and Engineering Company, Limited, Newcastle-on-Tyne. 1882.

Note.—The engines develop 1,000 to 1,100 indicated horse-power, and have cylinders of 34 and 66 ins. diameter. Stroke 42 ins. They are supplied with steam by two boilers at 80 lbs. per sq. in. Each boiler is 13 ft. 4 ins. diameter, and 10 ft. 6 ins. long. The consumption of coal is 18 tons per diem. Speed of vessels 10 to 12 knots per hour.

26. MODEL in metal. Patent multitubular marine steam boiler, designed for and used in the vessels of the Indian Rivers Steam Navigation Flotilla Company, 1877.

Lent by Captain G. J. Scott, M.M., 5, St. Swithin Street, Aberdeen, and late of Calcutta. 1883.

Note.—Mr. G. J. Scott, in 1875, devised at Calcutta the boilers represented by this model for service of the steamboats under his superintendence working on rivers of India whose waters were liable to rapid changes from clear to turbid and muddy. The boilers appear to have turned out highly successful in steam generating and self-cleansing. Their arrangement differs from the ordinary marine boilers, by reason of the methods of mud and deposit legs, the furnaces placed between the boilers returning through the

tubes and back again round the steam receiver on the boiler top, and ample water and steam space. Steam at 90 to 130 lbs. per square inch is the working pressure of the boilers.

27. PHOTOGRAPH. Boilers for steamers of the Indian Flotilla Company.

Lent by Messrs. Alley and McLellan, Sentinel Works, Glasgow. 1885.

Note.—The photograph represents a pair of single-ended boilers fired front to front, with their uptakes running into a single funnel overhead between them.

For photographs of screw and paddle-wheel engines, also by Alley and McLellan, see pages 184, 194.

28. DRAWING, coloured. Scale of ¾ in. to 1 ft., showing front elevation, sections and details of boilers fitted to supply steam to the engines arranged on Holt's tandem system.

Lent by Messrs. Robert Stephenson & Co., Newcastle-on-Tyne. 1886.

Note.—The heating surface of these boilers is 5,015 sq. ft., grate surface 153 sq. ft. Weight of boilers without fittings 64 tons, weight of boiler in working trim 159 tons.

These boilers and engines, constructed by Messrs. Stephenson, have been fitted to the Ocean Steamship Navigation Company's Liverpool steamers "PELAMED," "PROMETHEUS," "PALINURUS," and "DARDANUS."

For drawing of engines arranged on Holt's tandem system, see page 197.

29. DRAWING, coloured. G. Ferrando's system of forced draught for marine boilers.

Lent by Messrs. Scott Brothers, Newcastle-on-Tyne. 1886.

Note.—By means of this system of forced draught, "Duff" coal can be used as well as large coal. The following steamships have been fitted with the forced draught apparatus on Ferrando's system:—"ODIEL," "CALANAS," "PALOMARES," "LINARES," "MANTANA," "MOUNT TABOR," "MOUNT OLIVET," &c.

The "ODIEL" steamship and "CALANAS" steamship realised such economy on voyages from the Tyne to Lisbon, the Mediterranean and back, that Ferrendo's forced draught system using "Duff" coal firmly established itself for burning satisfactorily small or dust coal in the furnaces of marine boilers the fire-bars of which depart from the usual form of them in order to carry and consume "Duff."

30. PHOTOGRAPHS, TWO. Triple-furnace, marine steam boiler. Diameter 14 ft., length 10 ft. 6½ ins. Working pressure 165 lbs.

Lent by Mr. J. T. Eltringham, Stone Quay Works, South Shields. 1887.

Note.—The two photographs show one of a set of eight boilers constructed for the steamship "IMPERATOR," a vessel belonging to the Austro-Hungarian Lloyd's Steam Navigation Company, Trieste. The back and front view of these boilers, constructed by Mr. Eltringham, are represented.

31. PHOTOGRAPH. Triple-furnace, double-ended, marine steam boiler. Diameter 14 ft., length 18 ft. 2 ins., working pressure 165 lbs.

Lent by Mr. J. T. Eltringham, Stone Quay Works, South Shields. 1887.

Note.—The boiler represented in the photograph is one of six constructed for the Austro-Hungarian Lloyd's Steam Navigation Company, Trieste. The front view only is represented of this double-ended boiler, constructed by Mr. Eltringham.

32. PHOTOGRAPH. Boiler of the steamship "ANDALUCIA."

Lent by Mr. J. T. Eltringham, Stone Quay Works, South Shields. 1887.

Note.—The photograph represents the front of this single boiler. It has three furnaces, a steam dome or receiver on top, spring safety valves, smoke chamber and uptake, with the rest of the usual needful fittings. The boiler was constructed by Mr. Eltringham for Messrs. A. Leslie & Co., of Hebburn-on-Tyne.

33. PHOTOGRAPHS, TWO. Triple-furnace marine steam boiler, with Fox's corrugated flues. Built of steel, and riveted wholly by hydraulic machine. Diameter of boiler 14 ft. 6 ins., length 11 ft. 2 ins., working pressure 150 lbs.

The Wallsend Slipway and Engineering Company, Newcastle-on-Tyne. 1887.

Note.—The photographs represent front and back of the boiler in process of construction, with the hydraulic riveter in its working positions. The boiler is built so far as to show in the front view the furnace flues of corrugated steel, the tubes and their connexions to the tube plate, mud holes, and stay rod heads; in the back view the stays, and stay-rod heads, as they appear in the completed back end of the boiler.

34. MODEL. Corrugated furnace flue for marine steam boilers, 1887.

Lent by the Farnley Iron Company, Leeds, Yorkshire. 1887.

Note.—The corrugated furnace flues connected with the name (since 1875–6) of Mr. Samson Fox, of the Leeds Forge Company, are in general use for marine boilers. In his method the corrugations are parallel and regular around the furnace flue; but in the new departure, represented by this model, the corrugations are helical or screw-like throughout the flue length, a system brought out in 1887 by the Farnley Ironworks Company.

35. DRAWING. Boiler of the screw yacht "GLADIATOR." Built 1886.

Lent by Messrs. Ramage and Ferguson, Leith. 1887.

Note.—The boiler is shown in section. It supplies steam for the triple-expansion engines of the screw yacht "GLADIATOR" and is constructed of Siemens-Martin steel throughout. Heating surface of tubes 410 sq. ft. Grate surface 15 ft. Working steam pressure 150 lbs. per square inch. The boiler supplies steam to a set of three-cylinder three-crank compound engines of 162 indicated horse-power.

For engines of screw yacht "Gladiator," see page 203.

36. DRAWINGS, in one frame. Scale ¾ in. to 1 ft. Kemp's patent compound (high and low temperature) boiler.

Lent by Messrs. Alexander Stephen & Sons, Linthouse, Govan. 1887.

Note.—The drawings show :—

1. Details of boilers on Kemp's system fitted to the steamship "BLEVILLE." Built by the exhibitors 1886. The dimensions of the vessel, engines, and boilers, are as follows :—Vessel 300 ft. long, 40 ft. wide, 24 ft. 6 ins. deep, Engines, triple-expansion, cylinders 21 ins., 33 ins., and 52 ins. diameter. Stroke 42 ins.

Boilers, high temperature.—Two boilers 10 ft. 7 ins. diameter, 10 ft. long. Two furnaces in each 3 ft. 6 ins. diameter. 108 iron tubes in each 3½ ins. diameter and 7 ft. ½ in. long. Total heating surface in two boilers 1,768 sq. ft. Total fire-grate surface in two boilers 72 sq. ft.

Boilers, low temperature.—360 iron tubes, of four sections in each, 2 ins. diameter and 9 ft. long. Total heating surface in two boilers 3,393 sq. ft. Gross heating surface 5,161 sq. ft. Working pressure 160 lbs.

2. Details of improved type of Kemp's compound boiler. High temperature boiler 11 ft. 6 ins. diameter, 12 ft. long,

with three furnaces 3 ft. diameter, 114 iron tubes 3½ ins. diameter, and 8 ft. 6 ins. long. Total heating surface 1,176 square feet.

Low temperature boiler.—472 iron tubes 2½ ins. diameter, 8 ft. 6 ins. long, in four shells 3 ft. 10 ins. diameter. Total heating surface 2,626 sq. ft. Gross heating surface 3,802 sq. ft. Working steam pressure 160 lbs. per square inch.

37. SECTIONAL MODEL. Multi-tube marine steam boiler. Patented by the Earl of Dundonald, 1848.
Presented 1861.
Transferred from the Patent Museum. 1887.

Note.—Admiral Lord Dundonald was a celebrated inventor in marine engineering. The boilers represented by the model were the parents of the present multitubular system for marine steam boilers. Lord Dundonald is, however, perhaps better known in connexion with H.M.'s paddle-wheel gunboat "JANUS," built at Deptford or Woolwich in 1844 from his designs, 763 tons burden, 200 nominal horse-power. The "JANUS" was built double-ended so as to run at uniform speed either end first.

38. Two specimens of IRON BOILER PLATE. (A) atlas iron plate; (B) best iron plate for boilers.
From the Atlas Steel and Iron Works, Sheffield. 1864.

39. Piece of BOILER SCALE, from the steam boiler of a land engine. The specimen (polished) clearly shows the formation, and defines the adhesion to the boiler plates.
Presented. 1871.

40. MODEL. Scale 1 in. to 1 ft. Marine steam boiler of Admiralty pattern. Constructed to take to pieces and show general internal and external arrangements. Prepared by the Admiralty for the Science and Art Department.
Purchased. 1888.

Note.—The model illustrates steam boilers of design and form approved by the Marine Engineering Department of the Admiralty for H.M.'s ships of the Royal Navy. The boilers are constructed of steel, and work at a steam pressure exceeding 100 lbs. per square inch.

41. MODEL. Scale ½ in. to 1 ft. The stokehold of H.M.S. "INFLEXIBLE." Built at Portsmouth 1874–5. Illustrating the natural ventilation of the stokehold. The engines and boilers furnished by J. Elder & Co., Fairfield, Govan, Glasgow, 1878. Indicated horse-power 8,000.
The Admiralty. Purchased. 1888.

42. MODEL. Scale ½ in. to 1 ft. The stokehold of H.M.S. "TRAFALGAR." Built at Portsmouth 1886–7. Showing the forced-draught system, and the ventilation of the stokehold. Indicated horse-power 12,000.
The Admiralty. Purchased. 1888.

43. MODEL. Scale ½ in. to 1 ft. The forced-draught arrangements to the boilers of H.M.S. "MERSEY." Built at Chatham 1885. Indicated horse-power 6,000.
The Admiralty. Purchased. 1888.

44. MODEL. Scale ½ in. to 1 ft. Illustrating the forced-draught system of James Howden for marine steam boilers. 1883–4.
The Admiralty. Purchased. 1888.

45. MODEL. Scale ½ in. to 1 ft. Illustrating the forced-draught system of D. C. Green for marine steam boilers. 1887.
The Admiralty. Purchased. 1888.

46. MODEL. Scale ½ in. to 1 ft. Illustrating the forced-draught arrangements of W. A. Martin, 1885, for marine steam boilers.
The Admiralty. Purchased. 1888.

47. MODEL. Scale ½ in. to 1 ft. Illustrating the forced-draught arrangements for marine steam boilers of G. Ferrando. 1886.
The Admiralty. Purchased. 1888.

48. MODEL. Scale 1 in. to 1 ft. Illustrating the forced-draught arrangements of Messrs. J. I. Thornycroft for the marine steam boilers in swift torpedo vessels.
The Admiralty. Purchased. 1888.

49. MODEL. Scale 1 in. to 1 ft. Illustrating the forced-draught arrangements of Messrs. Yarrow & Co. for the marine steam boilers in swift torpedo vessels.
The Admiralty. Purchased. 1888.

50. MARINE BOILER and ENGINES, for steam launches or torpedo boats. Admiralty pattern.
Mr. G. A. Mumford, Engineer, Colchester. 1888.

Note.—The boiler is fitted with forced-draught appliances; the engines are of the two-cylinder inverted compound condensing type, and run at high speed.

51. DONKEY ENGINE and PUMP, for feeding marine steam boilers with water.

Mr. G. A. Mumford, Engineer, Colchester. 1888.

52. MARINE BOILER and ENGINES, for steam launches and torpedo boats. Admiralty pattern.

Messrs. Plenty & Son, Engineers, Newbury. 1888.

Note.—The boiler is fitted with forced-draught appliances; the engines are two-cylinder inverted compound condensing. The working steam pressure of the boiler is over 100 lbs. per square inch. The engines run at high speed.

53. REEFING FUNNEL. MODEL in brass. Reefing funnel and steampipe for steamships. Invented by R. Taplin of H.M.'s Dockyard, Woolwich, 1848.

Contributed 1858.

Transferred from the Patent Museum. 1886.

54. REEFING FUNNEL. MODEL in copper. Reefing funnel for steamships.

Contributed 1861.

Transferred from the Patent Museum. 1886.

Note.—The model also represents a "raking" funnel or smoke stack.

55. REEFING FUNNEL. MODEL in brass. Reefing funnel and steam pipe for steamships.

Transferred from the Patent Museum. 1886.

Note.—Reefing or telescopic funnels for steam vessels, especially of the imperial marine, are still fitted up. Mr. Taplin's plans were adopted for all classes of steam line-of-battle ships. The funnels or smoke stacks of small steamers are usually hinged and balanced by counterpoise weights, permitting them to be lowered.

In 1818 Mr. G. Dodd devised a plan for lowering the funnels of his Thames river steamers.

Note.—In T. W. Trail's book, 1888, on steam boilers; A. Jamieson's book, 1888, on steam engines; G. V. C. Holmes' text book, 1887, on the steam engine; Professor T. M. Goodeve's book, 1879 and 1888, on the same subject; some serviceable information may be found on the principles, requirements, materials, and construction, involved in steam boilers.

CLASS III.

Main Engines for Steamships.

Note on Marine Engines.

It may be useful to give here in connexion with the models and drawings of marine engines, a short list of the various kinds of engines used for marine purposes, their technical names, and principal constructors.

R. Sennett's book on the marine steam engine, 1882; A. E. Seaton's Manual of Marine Engineering, 1886; with Thomas Tredgold's work on the steam engine, 1838; and John Bourne's works on the same subject, 1868 and 1872; are full of historical and practical information.

1. Paddle Wheel Engines.

Side lever engines	Engineers of London, the Clyde, and others.
Vertical Engines	Engineers of London, Liverpool, &c.
Steeple engines	Engineers on the Clyde chiefly.
Inclined cylinder engines	Engineers of England and Scotland.
Oscillating or vibrating cylinder engines	Engineers of London, the Clyde, Belfast, and many others.
Half beam engines usually fitted in paddle wheel tug boats	Engineers of London, Liverpool, the Clyde, Belfast, and all seaport towns.

All these engines for driving paddle-wheels are however now very nearly obsolete, except in the case of oscillating cylinder engines (brought out in 1827 by Mr. Joseph Maudslay), and still used for high-speed steam vessels; and the half beam engines fitted in paddle-wheel tugs. The rocking-beam engines of America, fitted in "side-wheel" steamers, may be noted as an original and peculiar form of paddle-engine.

2. Screw Propeller Engines.

Inclined cylinder engines Inverted cylinder engines on the simple and compound systems. Used for steamships of the merchant world	Engineers throughout England, Scotland, and Ireland. They are simply universal.
Horizontal cylinder engines on the simple and compound systems. Used chiefly for ships of war.	Engineers of England and Scotland chiefly.

Some war ships have been fitted with screw propeller engines having cylinders inclined inwards and working inwards; others again have had fitted to them vertical or upright engines with inverted cylinders, and working direct downwards. The principle forms of screw engine adopted for ships of war, however, are those in which the cylinders lie on their sides horizontally, and drive their crank-shafts, which lie parallel to or along ships' keel line, by direct action or connecting-rod motion with the crank-shaft.

3. Compound Engines.

The marine engine working on the high and low steam pressure system, known as the "compound engine" appeared about 1856–1860. Compound engines are adopted for all kinds of uses ashore and afloat, and are severally known as engines arranged on the ordinary compound or two-cylinder plan, triple expansion engines with three or more cylinders, quadruple expansion engines with four or more cylinders, and so on. The system simply described is the using very high pressure steam in a small cylinder to drive the piston and allowing the same steam from it to expand in larger cylinders and drive their pistons, until the steam at a low pressure is finally admitted to and condensed in the condenser. The compound engine known as the "receiver" type of engine, in which the steam exhausted from the high pressure cylinder enters a "receiver" and there waits until the low pressure cylinder is ready to receive it, is believed to have been considered by Nicholson; by McNab; by E. A. Cowper, 1856, improved by him, 1862. The receiver is now generally applied to compound engines.

The compound engine was devised by Hornblower in 1781, and by Wolff in 1804.

4. Electric Motors.

The application of electricity in lieu of steam as a motive power to drive screw propeller vessels should also be shortly mentioned. In this direction it seems manifest that a very important part may be played by electricity.

As yet however it has not reached further than the propulsion of small craft. So far back as 1839 it would appear that Professor Jacobi, of St. Petersburg, ran a boat on the Neva driven by electric power. In 1860 M. Trouvé, at Paris, on the Seine, ran an electric motor boat. In 1881 an improved vessel was turned out by M. Trouvé, and in 1886–7 he completed still further improvements, both in the boat and her motive power.

In England in 1882 appeared on the Thames the electric power screw propeller launch "Electricity," her power amounted to $3\frac{1}{11}$ indicated horse power. Another vessel, the "Volta," built and equipped in 1886, on the Thames, proved herself a successful electric motor driven vessel. In the

summer months of that year she crossed with ease and speed, considering her small size, the Channel from Dover to Calais and back. The "VICTORIA" a larger craft than the "VOLTA," built 1887 by Lester and Perkins was turned out on the Thames with general approbation and success. Her dimensions were 90 ft. in length, 11½ ft. beam. Her driving power was fitted by the Electric Locomotive and Power Co., 6, Great Winchester Street Buildings. Mr. T. Nordenfeldt, of Parliament Street and Erith, is at the latter place now (1888) constructing of steel a vessel for Imperial torpedo service, to be driven by and solely dependent upon electricity for her propulsion. Messrs. Immisch & Co., London, have recently turned out successfully several pleasure launches fitted with electric motors.

5. SPIRIT MOTORS.

For some account of motors using spirit steam in lieu of water steam. *See note on boilers, p.* 162.

PADDLE ENGINES.

56. MODEL, on a scale of 1½ ins. to 1 ft. The oscillating cylinder paddle-wheel CONDENSING ENGINES of the Holyhead and Kingstown Royal Irish Mail Steamer "LEINSTER." 750 horse-power, nominal. Diameter of cylinders, 98 ins.; stroke, 6 ft. 6 ins.

To the engines are attached, on the same scale, the feathering float paddle-wheels of the ship; which are 32 ft. in diameter. The floats are 12 ft. long by 4 ft. 10 ins. deep.

Lent by Messrs. Ravenhill, Easton, and Co., London. 1869.

Note.—The length of the "LEINSTER" is 350 ft. over all. Beam 35 ft., depth of hold 21 ft. Tons 2,000. The ship has 8 boilers, 4 fore and 4 aft the engines, having 40 furnaces fired in line with the keel. The draught of the ship is 8 ft. 6 ins. on an even keel, and her speed about 21 statute miles per hour. She was built by Messrs. Samuda Brothers, Poplar, in 1860.

57. MODEL of the Engines of the paddle-wheel steamer "HELEN MCGREGOR," of Liverpool.

Designed and arranged in 1843 by G. Forrester & Co. Engineers.

Lent by Messrs. G. Forrester & Co., Liverpool. 1869.

Note.—This engine has two inverted steam cylinders driving one crank on paddle shaft, with a very long stroke. It occupies very little hull space. The engine is a condensing low-pressure engine, and is said to have been still at work in 1873.

58. MODEL of a paddle marine engine. Designed by J. Scott Russell, F.R.S., having three oscillating cylinders all connected to one crank on the paddle shaft. One of the cylinders is vertical, the other two are inclined inwards at about 45°.

Lent by the late Mr. J. Scott Russell F.R.S. 1869.

The model made by the late Jabez James, Lambeth.

59A. WATER-COLOUR DRAWING. The oscillating cylinder engines, fore and aft sets of boilers, and the feathering float paddle-wheels of the Sydney and Melbourne Royal Mail steamship "PACIFIC." 500 horse-power, nominal. These engines, boilers, and paddle-wheels, together with the ship, were designed and built by Mr. John Scott Russell, F.R.S., about 1854. Scale $\frac{1}{2}$ in. to 1 ft.

Lent by the late Mr. John Scott Russell, F.R.S. 1868.

Note.—This drawing shows side elevation of the engines and paddle-wheels. A front elevation of the boilers, which are placed parallel to the keel line. Also a plan of the engines, and fore and aft sets of boilers.

The boilers are separated from the cargo space and engine room by wrought-iron water-tight bulkheads.

59B. WATER-COLOUR DRAWING. Longitudinal through section of the "GREAT EASTERN" steamship. Showing details and arrangements of the paddle-wheel and screw-propellor engines, fore and aft sets of boilers, and other steam machinery of the ship. Scale $\frac{1}{8}$ in. to 1 ft.

Lent by the late Mr. John Scott Russell, F.R.S. 1868.

Note.—The "GREAT EASTERN" steamship (originally called the "LEVIATHAN") was designed by the celebrated engineer I. K. Brunel, about 1852. He was born in 1806, and died in 1859. His father, Sir Isambard Brunel, the engineer of the Thames Tunnel, begun 1825, opened 1843; the Great Western Railway broad-gauge system, 1839–1841, and many other large works, was born in Normandy in 1769, and died in 1849, in England.

The "GREAT EASTERN" was built of iron by Messrs. J. Scott Russell & Co., in 1857. She was laid down and launched broadside into the Thames at their shipbuilding establishment at Millwall.

The drawing represents a longitudinal through section of the ship, showing the emplacement of the engines for driving the paddle-wheels and screw propeller, the ships' boilers, coal bunkers, and other machinery detail.

The paddle-engines are 1,000 horse-power, nominal, the screw engines are of 1,700 horse-power, nominal.

The former were designed and constructed by Mr. J. Scott Russell. They consist of two distinct engines having a pair of oscillating inclined cylinders of 74 ins. in diameter and a stroke of 14 ft., separate air pumps, condensers, &c., complete. These engines drive paddle-wheels 56 ft. in diameter.

The screw engines were constructed by Messrs. James Watt & Co., Birmingham. They are of the horizontal type, having four cylinders, each 85 ins. in diameter, with a stroke of 4 feet. A pair of cylinders lying opposite to each other drive through connecting rods the main and screw shaft. The screw is 24 ft. in diameter and 44 ft. pitch. It weighs 36 tons. The boilers, 10 in number, supplied steam at 15 lbs. to 25 lbs. pressure per square inch to the paddle and screw engines.

60. PHOTOGRAPH of a double cylinder paddle-boat engine, with vertical steam boiler.

Presented by Messrs. Alexander Chaplin & Co., Glasgow. 1874.

61. THE ORIGINAL MARINE STEAM ENGINE. Made for Patrick Miller, Esq., by William Symington, Engineer, 1787, and used by him in a boat on the lake at Dalswinton, N.B., 1788.

Lent by Mrs. Bennet Woodcroft. 1876.

Note.—For some years prior to 1787 Patrick Miller, Esq., of Dalswinton, Scotland, had been engaged in a series of experiments with double and triple vessels propelled by paddle-wheels, worked by manual labour. In the experimental trips of 1786 and 1787, he was assisted by Mr. James Taylor (the tutor to his younger sons), and at the suggestion of Mr. Taylor it was determined to substitute steam power for manual labour. For this purpose, in the early part of 1788, Taylor introduced William Symington, an engineer at Wanlockhead Lead mines, who had previously obtained letters patent (June 5, 1787, No. 1,610) for "his new invented steam engine on principles 'entirely new.'"

An arrangement was made with Symington to apply an engine, constructed according to his invention, to one of Mr. Miller's vessels, and consequently the engine which forms the subject of this notice was made, the castings being executed in brass by George Watt, founder, of Low Calton, Edinburgh, in 1788. At the beginning of October in that year the engine, mounted in a frame, was placed upon the deck of a double pleasure boat, 25 ft. long by 7 ft., and connected with two paddle-wheels, one forward and the other abaft the engine, in the space between the two hulls of the double boat. On the steam-engine being put in action it propelled the vessel along Dalswinton Lake at the rate of 5 miles an hour.

62. The ORIGINAL ENGINE of Henry Bell's steamboat "COMET," which was the first steamboat in Europe advertised for the conveyance of passengers and goods. 1812.

Note.—This engine of 4 horse-power, nominal, on the low pressure condensing system, has a single upright cylinder, driving by means of connecting rods and side levers, the air pump and a single crank on the shaft on which is keyed a heavy fly wheel. It was made by John Robertson, mechanician, of Glasgow, and fitted on board the "COMET," in 1812. The paddles of the "COMET," four in number, were driven by gear wheels. Subsequently the boat was driven by two wheels only. The speed of the "COMET," was about 4 miles per hour.

This historical marine engine was presented in 1862 to the Patent Museum by Messrs. R. and J. Napier, Lancefield House, Glasgow.

Transferred from the Patent Museum. 1885.

63. PHOTOGRAPH. Rankin and Blackmore's two-cylinder inclined compound engines for paddle-wheel tug "MOUNT ETNA," 1880. Cylinders are 25 and 48 ins. diameter, stroke is 5 ft. The engines disconnect, so as to be used separately or together.

Lent by Messrs. Rankin and Blackmore, Eagle Foundry, Greenock. 1881.

For other photographs of Rankin and Blackmore's engines, see pages 192, 197, 202.

64. WORKING MODEL. Mr. Joseph Maudslay's original oscillating cylinder paddle-wheel engines. Patented 1827. (The arrangement for working the air pump is not that originally fitted.)

Contributed by Mr. J. Maudslay, 1857.
Transferred from the Patent Museum. 1885.

Note.—The paddle-wheel marine engines represented by this engine known at "oscillating cylinder" engines are favourites to this day for driving high-speed paddle-steamers. The advantages of the system are numerous, compactness of parts, absolute direct action, reduction of hull space, being chief. Messrs. Maudslay, Sons, and Field, however, did not continue the construction of this type of marine engine. The late Mr. John Penn (J. Penn & Son), of Greenwich, took them in hand about 1838, and from his works many sets of oscillating cylinder engines were turned out, both of small and great power, resulting in the engines being generally known as "Penn's oscillating engines." In 1856 Messrs. Randolph Elder & Co., of Glasgow, constructed a set of engines on the system of compound (high and low pressure) cylinders, and fitted them in the paddle steamers "INCA" and "VALPARAISO"

of the Pacific Steam Co. In 1860 surface condensers were applied and steam full jacketed cylinders used. The boiler steam pressure in 1856 of 25 lbs. per square inch, was raised in 1860 to 40 lbs., and in 1870 to 60 lbs. per square inch. In 1872 Messrs. Laird Bros. adopted the compound system for oscillating engines, since which time this system has been applied to oscillating engines having two driving cylinders only, or inclined cylinders, which (high and low pressure) work on to each crank on the main shaft of the engines. The paddle-wheel mail steamer "IRELAND," Holyhead and Kingstown service, built 1885, 6,000 indicated horse-power, and "MONA'S QUEEN," paddle-steamer, Isle of Man service, built 1885, 5,000 indicated horse-power, have representative compound oscillating cylinder engines of the recent types. The "IRELAND" was built by Laird Brothers, Birkenhead; "MONA'S QUEEN" by the Naval Construction Co., Barrow-in-Furness.

65. Paddle engines. MODEL. The four-cylinder inclined or diagonal oscillating paddle-wheel engines of the steamship "GREAT EASTERN," built 1857. Designed by the late John Scott Russell, F.R.S., 1853. Constructed by Messrs. John Scott Russell & Co.

Contributed 1857.

Transferred from the Patent Museum. 1885.

Note.—The paddle engines represented are 1,000 nominal horse-power, and form two distinct double-cylinder engines, each having its own air-pump, condenser, starting and stopping gear, and all needful accessories. The cylinders are each 74 ins. in diameter, with a stroke of 14 ft., the piston making 14 strokes per minute. A pair of cylinders work on and drive directly a single crank on the main shaft. The two inclined air-pumps are driven by a single crank. The paddle wheels represented are 58 ft. in diameter, and are capable of disconnexion from the engines. See also page 195.

66. Paddle engines. MODEL. A pair of side-lever engines for paddle-wheel steamships.—1827–1867.

Contributed 1868.

Transferred from the Patent Museum. 1885.

Note.—This class or type of marine engine, known as the side-lever engine, was for many years the especial favourite for long voyage steamers. They were constructed by Boulton and Watt, so far back as 1820, and afterwards by all the chief marine engine builders of Britain; many celebrated paddle-wheel steamers were driven by them. From 1837 to 1867 side-lever engines were at work on a more or less extended scale. The paddle steamships of the Peninsular and Oriental Company, the Royal Mail Company, the Atlantic liners of the Cunard Company, and the Collins Company, were, many of them, engined on this system. As examples

of approved types of these engines may be mentioned the paddle steamers "RUBY," on the Thames, built 1836. "RED ROVER," on the Thames, 1844. The "LONDON," London and Dundee, "CITY OF LONDON," London and Aberdeen trade, both built about 1844. The "PERSIA," Cunard liner, built 1856. The "SCOTIA," Cunard liner, built 1861. The "ADRIATIC," American steamer, of the Collins Atlantic U.S.A. line, 1850 to 1860.

67. Paddle engines. MODEL. A single side-lever engine with double working cylinders. "A double-cylinder side-lever engine."

Contributed 1868.

Transferred from the Patent Museum. 1885.

Note.—This model represents a novelty in the construction of a side-lever engine. The second working cylinder with its piston and piston-rod connexions placed directly under the crank shaft and helping the main working cylinder to drive it, is the specialty. The mode of connecting the second or forward cylinder to the crank should be noted.

68. Paddle engines. MODEL. Inverted double-cylinder direct-acting paddle-wheel engine. Designed and constructed, 1843, by G. Forrester & Co., Engineers, Liverpool.

Contributed 1860.

Transferred from the Patent Museum. 1886.

Note.—This model represents the engine in its place in the hull of a steamer. It was fitted in 1843 to the paddle steamer "HELEN MCGREGOR," 248 nominal horse-power, of Liverpool. A larger model of the same engines is exhibited in the collection. See also No. 57.

69A. Paddle engines. MODEL. Section of a steam vessel fitted with double-cylinder direct-acting paddle-wheel engines. Designed and constructed by J. Maudslay and J. Field, 1839–1841.

Contributed 1858.

Transferred from the Patent Museum. 1885.

Note.—This type of paddle-wheel engine is known as "Siamese engines," from the twin or double-cylinders with a T cross-head common to both pistons and piston rods, working down between the cylinders, whose outsides form a steadying guide to the cross-head and its connexion with the crank and shaft. Maudslay and Field, in 1844, fitted a set of these engines to H.M.'s paddle-wheel steam frigate "RETRIBUTION," built 1844, by Sir William Symonds, 1,641 tons burden, 800 nominal horse-power. She was a notable steam frigate. H.M.'s paddle frigate "TERRIBLE," built 1845, was also furnished with similar engines to the "RETRIBUTION."

69B. Paddle engines. MODEL. Section of a steam vessel fitted with double-cylinder direct-acting paddle-wheel engines. Designed and constructed by J. Maudslay and J. Field.—1839–1841.

Contributed 1858.

Transferred from the Patent Museum. 1885.

Note.—This model, on a smaller scale than the preceding, represents the same type of engine and its emplacement in the hull of a steamer.

70. Paddle engines. MODEL. Section of a steam vessel fitted with double piston-rod, engine, and portion of a paddle-wheel. J. Maudslay and J. Field, designers and constructors, 1839–40.

Contributed 1858.

Transferred from the Patent Museum. 1885.

Note.—The improvement or alteration in these engines chiefly consisted in the employment of two piston rods attached to the same piston working in a cylinder of a larger area than usual. The increased piston area necessitated the use of the two piston rods to balance the piston and avoid excessive weight of a single rod; at same time the engine should develop increased power on a reduced amount of length space occupied, and of weight in the steamer's hull.

71. Paddle engines. MODEL. Direct-acting, paddle-wheel engine. J. Miller's patent, 1841.

Contributed, 1858.

Transferred from the Patent Museum. 1885.

Note.—This set of direct-acting engines were brought out by Miller and Ravenhill, engineers, of Blackwall. They represent a type of vertical engine, designed 1840–41, by Miller, and merit attention from the following features. They occupy the least amount of length space in a steamer's hull. They comprise two steam cylinders with their slide valves, pistons, and piston rods, driving directly the overhead crank shaft, on which the cranks are set at right angles. Two air-pumps, working within the condenser, are also provided, one for each cylinder, an appreciable advantage in case of a break-down, as either air-pump will operate on both cylinders if required. The air-pumps are driven by a pair of cranks on the intermediate shaft in this engine, but afterwards changed to a single crank driving two pumps in the same vertical plane, but lying at an angle to permit the adaptation. Later in this class of direct-acting engines large eccentrics on the intermediate shaft have been substituted for the cranks to drive the air-pumps, whereby the shaft could be made in one straight piece.

72. Paddle engines. MODEL. Direct-acting, paddle-wheel engine. Designed and constructed by John Seaward, 1838.

Contributed about 1860.
Transferred from the Patent Museum. 1885.

Note.—This form of direct-acting paddle-wheel engine, devised and constructed by John Seaward, a celebrated marine engineer established at Blackwall, is known as the "Gorgon" type of engine from the circumstance that H.M.'s steam frigate "GORGON," built 1837, 320 nominal horse-power, was fitted with a pair of these engines. The paddle-wheel steam frigates "CYCLOPS," built 1839, 320 nominal horse-power, and the "PENELOPE," built 1843, 700 nominal horse-power, were also furnished with engines of the "Gorgon" type.

The Seawards in 1850 devised a new form of direct-acting engines for paddle steamers known as Atmospheric engines. Their peculiarity consisted in their cylinders being open at the top, and consequently the down stroke of the piston was due to atmospheric pressure. The steamers "WONDER," Havre and Southampton service, and the "SAPPHIRE," Thames river steamboat, were fitted with "Atmospheric" engines.

A small working engine on the principle, having three open top cylinders, was exhibited by the Seawards at the Paris Universal Exhibition of 1855; it is preserved in the Conservatoire des Arts et Métiers, Paris.

73A. Marine engine slide valves and expansion gear. MOVING MODEL, in brass, showing in section the cylinder, piston, piston-rod, eccentrics, slide valves, and expansion gear, as arranged for the engines of H.M.'s steam frigate "AVENGER." J. Seaward's patent, 1846.

Contributed 1860.
Transferred from the Patent Museum. 1885.

Note.—This sectional model is mounted on a mahogany board, and represents the upright direct-acting engines of the paddle-wheel frigate "AVENGER."

73B. Marine engine slide valves and expansion gear. TWO MOVING MODELS, in brass, showing in section the cylinder, piston, piston-rod, eccentrics, slide valves, and expansion gear of marine engines. J. Seaward's patents, 1846.

Contributed 1860.
Transferred from the Patent Museum. 1885.

Note.—These sectional models are mounted on mahogany boards, and represent upright direct-acting engines having fixed or stationary cylinders.

74. Paddle-wheel disconnecting apparatus. WORKING MODEL, in wood, of a marine engine crank-shaft, showing a plan for disconnecting the crank-pins from the paddle-shaft. S. Seaward's patent, 1840.

Contributed 1861.

Transferred from the Patent Museum. 1885.

Note.—The model represents one method of achieving the disconnexion of paddle-wheels and shafts from the engines. By means of a screw working inside the arm of the paddle-shaft crank, a sliding lug or hollow piece could be raised or lowered so as to hold or clear at pleasure the fixed crank-pin on the arm of the engine crank.

75. Paddle-wheel disconnecting apparatus. WORKING MODEL, in wood, of a marine engine crank-shaft, showing a pair of cranks, each fitted differently with plans for disconnecting the crank-pins from the paddle-shaft. J. Seaward's patent, 1840.

Contributed 1861.

Transferred from the Patent Museum. 1885.

76. Paddle-wheel disconnecting apparatus. WORKING MODEL, in brass, showing a single crank of a marine engine, with a later method of disconnecting the crank-pins from the paddle-shaft than represented by the preceding models.

Contributed by Messrs. Maudslay, Son and Field, 1862.

Transferred from the Patent Museum. 1885.

Note.—The plan shown in this model is an improved arrangement of the method described under No. 74 of these paddle-wheel disconnecting models. Probably the plan here shown was carried out by Maudslay, Son and Field, about 1850.

To the present day paddle-wheel steamers, especially tugs and steam fishing trawlers, are fitted with an apparatus for disconnecting or connecting the paddle-wheels with the engines. The arrangement admits of one wheel being driven in a contrary direction to the other, or standing idle temporarily as required, and again coupling up engines and wheels for full power steaming.

77. SET OF FIVE PHOTOGRAPHS. Marine engines and boilers, constructed by Messrs. Alley and McLellan, Engineers, Sentinel Works, Glasgow.

Lent. 1885.

Note.—The photographs represent the following paddle engines:—

a. Compound horizontal inclined cylinder engines, direct-acting surface-condensing, and Joy's slide valve

driving gear. Nominal horse-power 60. Designed by J. McGregor.

b. Compound inclined cylinder engines of 500 indicated horse-power fitted to paddle steamers of the Indian Flotilla Company, 1884. The fore and aft views of these engines are photographed separately.

For photographs of a pair of steel marine boilers and sets of screw propeller engines constructed by Alley and McLellan, see pages 168, 194.

78. PHOTOGRAPH. Side-lever, surface-condensing paddle-wheel engines, constructed 1885, for the paddle tug "PENDENNIS," of Wisbech, owned by Messrs. English Brothers.

Lent by Messrs. Westgarth, English & Co., Middlesborough-on-Tees. 1887.

Note.—The engine is of the half lever type usually fitted to paddle-wheel steam tugs, but in this case the side levers appear unusually long. The diameter of the cylinder is 25 inches, the stroke 42 inches.

CLASS III.

Marine Steam Engines.

SCREW PROPELLER ENGINES.

80. MODEL, scale 1½ ins. to 1 ft. The horizontal condensing screw engines of H.M.'s turret ship "MONARCH," 8,164 tons. Built 1868. 1,100 horse-power, nominal.

Lent by Messrs. Humphrys and Tennant, Deptford. 1869.

Note.—The engines of H.M.S. "MONARCH" were designed and built in 1868 by the lenders of the model. The indicated horse power of them is 6,600 horses. The engines make 60 revolutions per minute, and are on the direct-acting principle, with return connecting-rods, and have surface condensers. There are four piston-rods to each engine piston. The cylinders are 120 ins. in diameter, having a stroke of 4 ft. 6 ins.

The condensers are of wrought iron, their tops being of cast-brass. They can be used either as surface or jet condensers. They contain 17,264 copper tubes, each 6 ft. long, giving large condensing surface per nominal horse-power. The water is driven through the condensers passing outside

the tubes, by a reciprocating pump, the inlet and outlet pipes being of ample diameter.

The cylinders of the engines are steam jacketed.

The crank shaft is 22 ins. in diameter, and the propeller shaft 18 ins.

The starting, stopping, and reversing gear is placed on a central platform between the cylinders and condensers of the engines.

The crossheads to piston rods are forged solid ; their guides have very large surfaces ; they are easily adjusted.

The boilers are tubular, having brass tubes. They contain 21,000 sq. ft. of heating surface, and about 770 sq. ft. of grate surface.

The ship's propeller is a two-bladed Griffith screw, of gunmetal, 23 ft. 6 ins. diameter, with adjustable pitch from 23 ft. 6 ins. to 28 ft. 6 ins. The propeller weighs 22 tons.

81. MODEL, scale 1 in. to 1 ft. The horizontal condensing screw engines of H.M.'s turret ship "PRINCE ALBERT." 2,529 tons. Built 1864. 500 horse-power, nominal.

Lent by Messrs. Humphrys and Tennant, Deptford. 1869.

Note.—The "PRINCE ALBERT" was built in 1864 by Messrs. Samuda. An armour-plated turret ship, 240 ft. in length, 48 ft. beam, 25 ft. 3 ins. in depth. The model is a representation of her engines, and she was fitted with a four-bladed screw propeller.

82. MODEL, on a $\frac{1}{10}$ scale. The horizontal condensing screw engines of H.M.'s ships "NELSON," built 1814; altered for the screw propeller 1860. "CONQUERER," built 1833; altered for the screw propeller 1859. "TAMAR," built 1863. The engines are of 500 horse-power, nominal. Diameter of cylinders 71 ins., stroke 3 ft.

Lent by Messrs. Ravenhill, Easton, & Co., Ratcliff, London. 1869.

83. MODEL (working), scale 3 ins. to 1 ft. The condensing vertical screw engines of the steamship "A LOPEZ." Cadiz and Havannah Spanish Mail Service.

Constructed by Messrs. Denny & Co., Dumbarton. Purchased. 1871.

Note.—The engines are constructed on the hammer or inverted cylinder principle, and have condensers, air and feed pumps, variable expansion gear, &c. The model is a complete working condensing engine of about 15 horse-power. It was made in 1866-7, and exhibited in motion at the Paris Universal Exhibition of 1867.

The condensers of these engines are on Spencer's surface plan, 1860. They comprise a large central box, on the top edges of which rest the cylinders, inverted. The piston rods, two to each piston, work down by the sides of the condenser, and move in guides carried by the sides of the box. The pumps are worked off the crossheads, which are suitably prolonged for the purpose.

84. DRAWING, scale 1 in. to 1 ft. The compound inverted cylinder screw engines of the steamships "EDINBURGH CASTLE" and "WINDSOR CASTLE." Built and engined in 1872 by the donors of the drawing.

Presented by Messrs. R. Napier & Sons, Glasgow. 1874.

Note.—The engines are of 270 horse-power, nominal, having surface condensers, air and feed pumps, link motion, for reversing, &c.

Diameter of high-pressure cylinder 44 ins.
Diameter of low-pressure cylinder 72 ins.
Stroke 3 ft. 6 ins.

The steamships belong to Messrs. Donald Currie & Co.'s Colonial Line of Mail Steamers, and run direct between London and the Cape of Good Hope.

85. PHOTOGRAPH of a double cylinder screw engine, for a single screw propeller, with horizontal steam tubular boiler.

Presented by Messrs. A. Chaplin & Co., Glasgow. 1874.

86. THREE DRAWINGS. The inclined cylinder screw engines of H.M.S. "CONSTANCE." Constructed for the ship in 1863 on the compound principle, by Randolph Elder & Co., Engineers, Glasgow.

Messrs. John Elder & Co., Glasgow. 1876.

Note.—These engines were the first ever fitted on the compound principle in any of H.M.'s ships. The engines comprise two high-pressure cylinders 60 ins. in diameter, and four low-pressure cylinders 78 ins. in diameter. The stroke is 3 ft. 3 ins. in length. The engines are fitted with surface condensers, air, bilge, and circulating pumps, and other modern arrangements. The drawings represent a plan of the engines, and two elevations of them as fitted in the ship, one looking forward, the other looking astern.

87. MODEL, in wood. The compound horizontal screw engines of H.M.'s ships "BOADICEA" and "BACCHANTE." 5,250 indicated horse-power. Built 1875–76.

Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

Note.—The engines on the compound system of these ships have three cylinders lying side by side, the centre one being high pressure, and the two others low pressure cylinders. The condensers are on the surface system, having independent pumps for water circulation. The engines are direct acting, and have all the modern arrangements for their control and economic working.

88. MODEL, in wood. The inverted cylinder compound engines of the Peninsular and Oriental Company's screw steamship "PERA." 2,000 indicated horse-power. Built 1872.

Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

Note.—These engines are on the upright or vertical system. They are direct-acting, and have injection condensers.

89. MODEL, in wood. Reversed horizontal marine screw engines. Built 1860.

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

Note.—In these engines the cylinder and condenser of each engine are set side by side, and lie opposite each other contrarywise, which arrangement necessitates one engine moving in the contrary direction to the other, and hence the name "reversed" engines. Only one or two sets of engines arranged in this manner have been built by the exhibitors. They are constructed on the principle known as the "trunk" system, for the piston and connecting rods of the engines. These engines are fitted with injection condensers.

90. SECTIONAL MODEL, in wood. Side by side cylinder horizontal compound engines. Designed by John Milner, 1853.

Mr. J. Warriner. 1876.

Note.—This sectional model represents one of the earliest proposals for applying the compound, or combined high and low pressure cylinder system, to marine steam engines. At the present time engines with combined high and low pressure cylinders, instead of the old form of equally sized cylinders, are now of constant application in marine engineering.

91. MODEL of Dawes and Holt's marine screw engine.

Mr. Henry P. Holt, Leeds. 1876.

Note.—This engine is of the vertical compound condensing inverted cylinder type, without intermediate receiver between high and low pressure cylinders, and very short passages, reverse action of pistons, parallel motion, single crank and connecting rod, one vertical and one horizontal air pump, the former forming a counterbalance to connecting rod, and the latter is arranged to be used as a starting cylinder when required.

93. DRAWING. Pair of compound marine screw engines of the vertical type. Constructed by John Dickinson, Engineer, Sunderland.

Lent. 1876.

Note.—The drawing represents a front elevation and a side view of these engines. They are constructed on the inverted cylinder system, having two cylinders, surface condensers, air circulating and bilge pumps, and other modern arrangements. The engines are of the larger class.

94. DRAWINGS. Compound surface-condensing marine engines.

Lent by Messrs. T. Richardson & Sons, Hartlepool. 1876.

Note.—Three drawings of marine engines of modern construction.

One drawing represents engines of the largest class, from 205 horse-power upwards, fitted with steam reversing gear, surface condensers, and other modern arrangements. Designed 1875.

Another drawing represents engines of a more moderate size, and gives the names of the vessels into which they have been fitted. Designed 1871–73.

A third drawing represents marine engines of the smaller class.

The three drawings all represent compound surface-condensing engines, for driving the screw propeller. These engines are all of the vertical inverted cylinder type designed by Mr. Charles Smith.

95. DRAWING. Design for a 60 horse-power low-pressure condensing engine, on the disc system of the late G. Rennie. 1855.

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

Note.—This form of engine for driving a screw propeller was designed with a view of gaining much economy in space, and of doing away with many of the working parts of the ordinary marine screw engine. In 1853 an engine on the "Disc" system of the late Mr. G. Rennie, (born 1791, died 1866), was fitted for trial on board H.M.S. "CRUISER," 17 guns; built 1852. Tonnage 752. The "Disc" engine is essentially a direct-acting engine. The drawing shows a section of the hull of the "CRUISER" with the emplacement of the disc engine, and an outline in red ink for comparison of the form and space occupied by the old engines in the vessel. The old engines and the disc engine were of the same nominal power of 60 horses.

96. MODEL, in metal and brass; on a scale of 1 in. to 1 ft. The horizontal screw engines of H.M.'s ships "MINOTAUR" and "NORTHUMBERLAND," 1866. Constructed on Penn's trunk system. Nominal horse-power 1,350.

Sir Trevor Lawrence, Bart. 1878.

Note.—The model represents a pair of engines having cylinders 100 ins. in diameter, and a stroke of 6 ft. The diameter of the trunks, 36 inches. The engines have surface condensers, air and bilge pumps, expansion gear, and link motion for driving and reversing the slide valves for admission of steam to the cylinders. The cranks on the engine shaft are balanced. The real engines and this model of them were constructed by Messrs. John Penn and Son, Engineers, Greenwich.

97. MODEL, in metal. The inverted cylinder surface condensing compound screw engines of Peninsular and Oriental Company's steamer "CARNATIC." Constructed and fitted to ship in 1863 by Messrs. Humphrys, Tennant, and Company, London.

The Peninsular and Oriental Steam Navigation Company, Leadenhall Street, E.C. 1878.

Note.—The screw engines of the "CARNATIC" were of 400 nominal horse-power, and 2,500 indicated horse-power. They were fitted with four, two high and two low, pressure cylinders of 43 and 96 ins. diameter respectively, and a stroke of 3 ft. The engines made 72 revolutions per minute on trial. The cylinders are placed one on top of the other. The air pumps are driven by separate piston rods. The condensers are formed in the engine framing.

98. MODEL. The inverted vertical cylinder, compound screw engines of the White Star Line steamship "BRITANNIC," Messrs. Maudslay, Sons, and Field, Engineers, London, 1874.

The White Star Line Company (Messrs. Ismay, Imrie, & Co.), Liverpool. 1879.

Note.—The White Star line screw steamship "BRITANNIC" was built of iron at Belfast by Messrs. Harland and Wolff, and launched February 1874. She is 480 ft. long, 50 ft. broad, 35 ft. depth of hold, and over 5,000 tons gross burden. Horse-power 760. Speed 16 knots.

The engines designed and constructed for the ship by Messrs. Maudslay, Sons, and Field, are of the vertical tandem cylinder compound type. They comprise four cylinders, the high pressure being directly over the low pressure cylinder.

The engines have surface condensers, circulating pumps, steam starting and stopping gear, together with the recent appliances and improvements attached to large screw engines. The model represents all the details of the real engines. The high pressure cylinders are 48 ins. in diameter, low pressure cylinders 83 ins. in diameter, stroke 5 ft. The engines make 50 to 55 revolutions per minute. The condensers have 4,762 tubes, 8½ ft. long and ¾ in. in diameter, giving an aggregate surface of 9,000 sq. ft. Centrifugal circulating pumps 5 ft. diameter are driven by a pair of engines with 12 in. cylinders and 15 in. stroke. Expansion valves are fitted to the high pressure cylinders, and work on the back of the ordinary slide valves. Steam is supplied by eight oval boilers 8 ft. 10 ins. wide, 14 ft. 4 ins. high, and 19 ft. 10 ins. long. The boilers are fired at both ends, and have each four furnaces, making 32 in all, with a grate area of 680 sq. ft. The boilers contain 2,432 tubes 7 ft. 2 ins. long, 3½ ins. diameter, giving total heating surface of 15,900 sq. ft. The engines develop 5,000 indicated horse-power.

99. MODEL, in Wood. Crank motion for inverted screw engines, designed by exhibitor, 1855.

Lent by Mr. T. F. Chappé, 29, Stanley Gardens, Notting Hill. 1879.

Note.—This model is a sectional model, showing a pair of steam cylinders obliquely inverted, with piston, piston rod, and connecting rod, driving through a link motion one crank on the shaft. The motion contemplated avoiding the engines hanging on the centre or dead-point of revolution, and they were arranged for gunboats of shallow draught, so as to bring the machinery below the boat's water-line.

100. DRAWING. Coloured drawing, scale 1 in. to 1 ft., showing front elevation and end elevation of the vertical engines, on the trunk system, 450 nominal horse-power, for the Peninsular and Oriental screw steamship "CANDIA," 2,100 tons. Messrs. J. and G. Rennie, Engineers.

Lent by the Peninsular and Oriental Steam Navigation Co., 122, Leadenhall Street, E.C. 1879.

Note.—The engines illustrated by this drawing were designed and constructed in 1854 by J. and G. Rennie, Engineers, Blackfriars, for the Peninsular and Oriental screw steamship "CANDIA." The engines had vertical fixed cylinders driving an overhead shaft, the screw of the ship being driven by multiplied gear.

101. PHOTOGRAPH. Two-cylinder inverted compound disconnecting screw engines, fitted by Rankin and Blackmore to twin-screw tug "WALRUS," 1877. The engines

disconnect, and can be driven independently, or connected together.

Lent by Messrs. Rankin and Blackmore, Eagle Foundry, Greenock. 1881.

Note.—A sister tug to "WALRUS," named the "OTTER," has similar engines by Messrs. Rankin and Blackmore; the cylinders are 13 and 24 ins. diameter respectively. Stroke, 20 inches. The screws are 6 ft. diameter.

For other photographs of Rankin and Blackmore engines, see pages 179, 197, 202.

102. PHOTOGRAPHS. Front and back end views. A set of marine compound horizontal two-cylinder screw engines, fitted with Marshall's reversing motion and slide valve driving gear.

Presented by Messrs. R. and W. Hawthorn, Newcastle. 1881.

Note.—These engines are at work in screw steamships in the Liverpool and South American trade. The high pressure cylinders are 30 ins. diameter, the low 60 ins. Stroke 36 inches. Engines run at 110 strokes per minute. Steam at 90 lbs. per square inch at boilers is used. Engines develop 2,700 indicated horse-power.

With these photographs are also exhibited indicator diagrams taken from similar engines.

103. MODEL. Complete model showing after end of ship and screw propeller. The two-cylinder inverted compound engines of the screw steamships "CITY OF "CALCUTTA," 1881, and "CITY OF CAMBRIDGE," 1882. 4,000 gross register tonnage; 650 nominal horse-power.

Messrs. J. and J. Thomson, Finnieston Iron Works, Glasgow. 1881.

Note.—The model represents engines having cylinders of 50 and 96 ins. diameter respectively for high and low pressure. The stroke is 5 ft. The real engines were constructed by Messrs. J. and J. Thomson, the model made from their plans and drawings of them.

104. PHOTOGRAPH. The inverted cylinder triple expansion compound engines of the steamship "ABERDEEN," built 1881. Gross register tons 3,616. Indicated horse-power 2,700.

Presented by Messrs. R. Napier and Sons, Glasgow. 1882.

Note.—The engines represented by the photograph have three inverted cylinders of unequal diameters but of uniform stroke. The high pressure cylinder is 30 ins. in diameter,

the intermediate cylinder is 45 ins., the low pressure cylinder is 70 ins. in diameter. Stroke 4½ ft. Speed of ship on a consumption of 1·58 lb. of coal per indicated horse-power per hour with 2,000 tons dead weight aboard, is 13·74 knots per hour. The steam pressure in the boilers is 125 lbs. per square inch. The boilers are of steel.

105. DRAWING. Coloured moving drawing; the two-cylinder inverted compound engines, by Messrs. J. and J. Thomson, Engineers, Finnieston Works, Glasgow, of the screw steamships "BROOKLYN" and "OTTAWA." 500 nominal horse-power. Scale of drawing 1 in. to 1 ft.

Messrs. Flinn, Main, and Montgomery, Liverpool. 1882.

Note.—These moving drawings of machinery are known as Batchelor's moving diagrams. Messrs. H. and T. C. Batchelor, West Kensington, London.

106. FOUR PHOTOGRAPHS. Engines of the Orient Steam Navigation Company's screw steamship "ORIENT." Tons, gross, 5,386. Built and engined, 1879, by John Elder & Co., Glasgow. The engines have one high-pressure cylinder of 60 ins. diameter, and two low-pressure cylinders of 85 ins. diameter. Stroke 5 ft. Nominal horse-power 1,000, indicated horse-power 5,400.

Presented by the Orient Steam Navigation Company, 13, Fenchurch Avenue, E.C. 1882.

Note.—The "ORIENT" is iron built, has watertight bulkheads and compartments throughout. She is a fast-steaming ocean ship, one of her voyages out to Melbourne in 1880 being accomplished in 34½ days.

107. PHOTOGRAPH. Triple-expansion engines of the steamship "ALBERTINA," and the steamship "CLAREMONT."

Lent by Messrs. Fisher, Renwick, & Co., Newcastle-on-Tyne. 1882.

Note.—These engines have cylinders of 14½, 20½, and 40 ins. diameter. Stroke 33 ins. They were designed by Mr. A. Taylor and constructed by Douglas and Grant, Kirkcaldy, N.B. Working pressure of boilers 150 lbs. per square inch.

The steamship "CLAREMONT" is 180 ft. long, 29 ft. beam, 13 ft. depth B.M., and 695 tons gross register.

The steamship "ALBERTINA" is 672 tons gross register.

108. PHOTOGRAPHS, THREE. Triple expansion engines of the steamship "MILLICENT." Built 1882-3 by the

exhibitors for Messrs. Fisher, Renwick, & Co., Newcastle-on-Tyne.

Lent by Messrs. Wigham, Richardson, & Co., Neptune Works, Newcastle-on-Tyne. 1883.

Note.—The engines are built on Mr. Alexander Taylor's system. Working pressure 150 lbs. per square inch. Diameter of high pressure cylinder 16½ ins., intermediate cylinder 22 inches, low pressure cylinder 44 inches. Diameter of boilers 12 ft. Length of boilers 10 ft. 7 ins. Heating surface 1,670 sq. ft. Grate surface 42 sq. ft.

The steamship "MILLICENT" is a cargo boat with raised deck to boiler bulkhead, top-gallant forecastle, cellular bracket bottom for water ballast. Length 195 ft., breadth 30 ft., depth of hold to ordinary floors 14 ft. Carrying capacity about 1,050 tons.

109. PHOTOGRAPHS, FIVE. Working drawings of details of screw engines and boilers built by Cox & Co.

No. 1. General arrangement of 70 N.H.P. marine engines. Cylinders 22 and 40 ins. diameter. Stroke 26 ins.

No. 2. Two views; elevation. Compound screw engines. Cylinders 10 and 18 ins. Stroke 14 ins.

No. 3. Two views; elevation. Compound screw engines. Cylinders 8 and 16 ins. Stroke 12 ins. Working pressure 110 lbs.

No. 4. Steel boiler; working pressure 95 lbs. per square inch. Suited for compound marine engines for yachts.

Presented by Messrs. Cox & Co., Falmouth. 1884.

110. PHOTOGRAPH. Set of compound, surface-condensing twin engines, for driving twin screw propellers, having four cylinders, two of 10 ins. and two of 18 ins. diameter. Stroke 14 ins. The pumps are worked by an independent engine.

Presented by Messrs. Cox & Co., Falmouth. 1885.

Note.—These engines are noteworthy for their light framing and general arrangement as twin screw and twin cylinder inclined engines.

111. PHOTOGRAPH. Inverted cylinder, surface-condensing screw engines. 250 indicated horse power.

Lent by Messrs. Alley and McLellan, Sentinel Works, Glasgow. 1885.

For photographs of paddle-wheel engines and boilers, see pages 168, 184.

112. SCREW ENGINES. Horizontal compound screw engines. Nominal horse-power 15. Indicated horse-power 56, with 80 lbs. per square inch steam pressure. Cylinders 9 ins. and 18 ins. diameter. Stroke 9 ins. Weight 3 tons.

Lent by Messrs. D. and W. Robertson (the London and Colonial Engineering Co.) 31, Lombard Street, E.C. 1885.

Note.—These engines represent a type of screw propeller engine designed for vessels of shallow depth and light draught. They are easily managed, and will apparently sustain much rough treatment. They were constructed by Messrs. Westgarth, English, & Co., Engineers, Middlesborough.

113. Screw engines. MODEL of the horizontal direct-acting screw engines of the steamship "GREAT EASTERN," 1857. Designed and constructed by Messrs. James Watt & Co., Engineers.

Contributed by Messrs. James Watt & Co., Soho, Birmingham, 1860.

Transferred from the Patent Museum. 1885.

Note.—These screw propeller engines are 1,700 nominal horse-power. They have four cylinders each 84 inches in diameter; stroke 4 ft. They drive a screw propeller 24 ft. diameter and 44 ft. pitch. *See also* page 180.

114. Screw engines. MODEL. Cross section of the ship, with the original screw engines of the steamship "GREAT BRITAIN," 1843.

Presented by Messrs. Gibbs, Bright & Co., 1862.

Transferred from the Patent Museum. 1885.

Note.—The screw engines of the steamship "GREAT BRITAIN," constructed by Messrs. Bolton and Watt, Soho, Birmingham, were 1,000 nominal horse-power. Each of the four cylinders were 88 ins. diameter, stroke 6 ft. The screw propeller was driven by chain gear running over a huge drum turned by the engine main shaft, and a smaller drum on the screw shaft, giving multiplied speed to the screw. These engines were subsequently replaced by J. Penn with a set of oscillating two-cylinder engines, driving spur wheel and pinion gearing and fitted with two inclined air pumps. Cylinders were 82 inches diameter; stroke 72 inches.

For a model of the steamship "Great Britain," 1843, see page 50.

115. Screw engines. MODEL of a pair of screw propeller engines. J. A. Limbert's patent, 1857.

Contributed 1860.

Transferred from Patent Museum. 1885.

Note.—The model represents a set of horizontal cylinder screw propeller engines for ships of war. They are constructed on the double piston rod and return connecting rod system, and are similar in principle to the engines of H.M.S. "CONQUEROR," 1859, and "TAMAR," 1863, by Ravenhill & Co., Ratcliffe, E. A model of the engines of the "CONQUEROR" and "TAMAR," is exhibited in the collection, *see* No. 82.

116. MODEL. Longitudinal section of steamship fitted with horizontal compensating (compound) engines, screw propeller, and rudder. J. G. Bodmer's patents, 1834, 1841, and 1844.

Contributed 1857.

Transferred from Patent Museum. 1885.

117. Screw engines. MODEL. Pair of inverted cylinder compensating (compound) engines for driving a screw propeller. J. G. Bodmer's patents, 1834, 1841, 1844.

Contributed 1857.

Transferred from Patent Museum. 1886.

118. MODEL. Two-bladed screw and bearings, fitted with multiplying gear for driving screw propellers. J. Maudslay's patent, 1843.

Contributed 1862.

Transferred from Patent Museum. 1885.

Note.—In the early days of the application of the screw propeller to drive a steamship, multiplying gear of some kind for increasing the screw speed and allowing the engines to run at a moderate speed was deemed a necessity. The "GREAT BRITAIN" steamship, 1843, was fitted with multiplying gear, and many other early screw propeller steamships. An example of the system was exhibited by Tod and McGregor, Engineers, Glasgow (now D. & W. Henderson), at the Paris Universal Exhibition of 1855, by a working engine on the steeple or upright system with multiplied toothed wheel gearing. The engine was afterwards exhibited at the Crystal Palace, Sydenham.

119. MODEL. Three-bladed screw and portion of shafting, bearers, &c., showing disconnecting apparatus for screw propellers. Designed by B. Hick. Messrs. Hick & Son., Engineers, Bolton, Lancashire.

Transferred from the Patent Museum. 1885.

120. WORKING MODEL in metal. A screw propeller shaft disconnector.

Lent by Mr. Hy. Emanuel, Surbiton, S.W. 1885.

For model of bilge-valve, rudder, and tiller, see pages 552, 260.

121. WORKING MODEL. A plan for communicating motion from the crank shaft of vertical marine engines to the screw propeller shaft of screw steamships. Inventor not known.

Contributed 1862.
Transferred from the Patent Museum. 1885.

122. SCREW ENGINES. Full size double cylinder inverted direct-acting compound surface-condensing screw engine. Cylinders 7½ ins. and 15 ins. diameter. Stroke 8 ins. Horse-power nominal 10; indicated 60.

Lent by Messrs. Matthew Paul & Co., Levenford Works, Dumbarton. 1886.

Note.—All the valve motions are obtained from one eccentric, giving variable cut-off and uniform lead.

123. DRAWING, coloured, on a scale of ½ in. to 1 ft. Transverse and longitudinal section of part of vessel showing front elevation and section of screw engines arranged on Holt's tandem system.

Lent by Messrs. Robert Stephenson & Co., Newcastle-on-Tyne. 1886.

Note.—The diameter of the high-pressure cylinder is 27 ins., the low-pressure cylinder 58 ins., stroke 5 ft., diameter of air-pump 18 ins., diameter of circulating pump (double-acting) 13½ ins., diameter of feed and bilge pumps 5½ ins., stroke of pumps 22½ ins. The single vertical engine has inverted cylinders, and is fitted with a heavy fly-wheel to carry over the dead points of the crank shaft. The S.S. "PROMETHEUS" and others ars fitted with engines on Holt's tandem cylinder compound system, 1881–1886, and are described in a paper by F. C. Marshall, 1881.

For drawing of boilers, see page 168.

124. PHOTOGRAPH. Rankin's Patent four-cylinder disconnecting triple-expansion compound engines. Fitted to the twin-screw steamship "ARABIAN," 1884.

Lent by Messrs. Rankin and Blackmore, Greenock. 1886.

Note.—These engines have two high-pressure cylinders of similar diameters, and two low-pressure cylinders of varying diameters, with an equal stroke throughout. The cylinders and pistons work tandem fashion, and either set of them can be run as a single engine separately, or combined together as a pair of engines. They are controlled from the upper deck of the ship. The condenser lies between the engines, with the air bilge, feed-pumps, &c. below it.

See pages 179, 192, 202.

125. Screw engines. MODEL, in brass. J. Ericsson's screw propeller engines fitted to American and Swedish monitors built in America, 1860–1865.

Patented in America 1858.
Presented 1865.
Transferred from the Patent Museum. 1886.

Note.—These engines were designed with a view to direct action on the screw propeller shaft and to great economy in the ship's hull space, required for the driving machinery. Two horizontal cylinders lie back to back athwart ships. Each piston-rod is connected to a rocking beam which is again connected through a return compound link motion to a single crank on the propeller shaft running along keel line. The engine accessories, air-pumps, and the like, were driven by the rocking shafts connected to the piston-rods.

126. WORKING MODEL, on a scale of 3 ins. to 1 ft. Triple expansion, surface-condensing, three-cylinder, three-crank engines, fitted to the screw steamer "FLAMBORO'," 1886.

Lent by Palmers' Shipbuilding and Iron Company, Jarrow-on-Tyne. 1887.

Note.—The engines of the steamship "FLAMBORO'," indicate 1,000 horse-power. Cylinders 22 ins., 35 ins., and 58 ins. diameter. Stroke 42 inches. The propeller is 15 ft. 4 ins. diameter, 17 ft. pitch, and has 54·8 sq. ft. surface. This model represents fully with complete detail a set of three-cylinder inverted compound engines driving three cranks on engine shaft; the approved type of engines for screw propeller steamships of the present time, and adopted for vessels of the Imperial services and of the mercantile marine.

127. PHOTOGRAPHS, TWO. The "BRITON." Horizontal compound surface-condensing screw engines. Cylinders 9 ins. and 18 ins. diameter, stroke 9 ins., horse-power 56 indicated.

Lent by Messrs. Westgarth, English, & Co., Middlesborough-on-Tees. 1887.

For a full size working example of these "Briton" screw engines, see No. 112.

128. PHOTOGRAPHS, TWO. Compound surface-condensing screw engines. Horse-power 99 nominal. Cylinders 26 ins., and 48 ins., diameter. Stroke 36 inches.

Lent by Messrs. Westgarth, English, & Co., Engineers, Middlesborough-on-Tees. 1887.

Note.—Engines of the above type have been built by the exhibitors for various vessels, viz:—the steamships

"STOKESLEY," "SUNRISE," "MYSOTIS," "CLAXTON," "SUNLIGHT," "CLEMATIS;" and with slight alterations for the screw steamers "HUNSTANTON," "CASTLE RISING," and "GODIVA."

129. PHOTOGRAPHS, TWO. Triple expansion screw engines, built for the steamship "WARRINGTON," 1886.
Lent by Westgarth, English, & Co., Middlesborough-on-Tees. 1887.

Note.—The steamships "WARRINGTON," and "NORTHENDEN," were built 1886 by Messrs. Swan and Hunter, Wallsend, Newcastle, for the Manchester, Sheffield, and Lincolnshire Railway Company, and run between Grimsby and Hamburg. The engines indicate 1,100 horse-power. The cylinders are 22 ins., 35 ins., and 57 ins. diameter. Stroke 42 inches.

130. PHOTOGRAPHS, THREE. Ordinary compound (two-cylinder) type of engines fitted to the screw steamers "POPLAR," "WAPPING," and "STEPNEY." Built 1886.
Presented by the Central Marine Engineering Company, West Hartlepool. 1887.

Note.—The screw steamers "STEPNEY," "WAPPING," and "POPLAR," are all fitted with the same type of two-cylinder inverted compound engines, indicated horse-power 650. The frames of the engines are somewhat novel, and depart from the usual form. The slide valve driving gear is also novel. The engines were constructed and completed from designs by Mr. Thomas Mudd, of the Central Engineering Co., West Hartlepool.

131. PHOTOGRAPHS, THREE. Triple expansion engines fitted to the screw steamers "ENFIELD," "FERNLANDS," 'COOT," "CLEVELAND," "BAKUIM," "ABEONA," and "ASTRÆA."
Presented by the Central Marine Engineering Company, West Hartlepool. 1887.

Note.—The steamship "COOT" was built 1886. Her engines are 750 indicated horse-power.

The "ENFIELD" was built 1885. She has similar engines to the "COOT," constructed from designs by Mr. Thomas Mudd, of the Central Engineering Co., West Hartlepool. The "COOT'S" engine cylinders are 19½ ins., 32½ ins., and 53 ins. diameter. Stroke 36 inches. They each drive a crank on main shaft, and are steam jacketed. The boiler steam-pressure is 150 lb. per square inch.

The steamship "CLEVELAND" has similar engines, but of larger size and power.

CLASS III.

Yacht and Launch Engines.

PADDLE ENGINES.—SCREW ENGINES.

134. PHOTOGRAPH of Brotherhood and Hardingham's three-cylinder high-pressure horizontal steam engine, adapted for river screw pleasure yacht propulsion. The engine was designed and patented by Mr. P. Brotherhood, in 1872–73.

Presented by Mr. P. Brotherhood, Lambeth. 1874.

135. PHOTOGRAPH of a twin screw vertical steam engine and upright boiler. For steam yacht, launches, &c.

Presented by Messrs. A. Chaplin & Co., Glasgow. 1874.

136. SCREW ENGINE. High-pressure non-condensing screw engine, 3 horse-power, for screw steam launches. Constructed on the hammer or inverted cylinder principle. Diameter of cylinder 5 ins. Stroke 6 inches.

Messrs. A. Verey & Co., Dover. 1875.

137. MARINE ENGINES. A set of inverted two-cylinder compound condensing engines of 20 nominal horse-power for a screw steam yacht.

Messrs. J. Copley & Co., Vulcan Works, Middlesborough. 1882.

Note.—These engines are of high speed. They run at 400 revolutions per minute. The air pump, condensing water circulation pump, bilge and feed pump, are all driven by worm and screw gearing at 100 strokes per minute through an independent horizontal and transverse shaft. The pumps are of novel arrangement, inasmuch as they are constructed on the same principle as the steam cylinders and slide valves, but the action is reversed. The pumps draw through their exhaust, and eject through their slide valve ports. The pumps are double acting.

138. SCREW ENGINES. Inverted double cylinder screw engines for steam launches. Diameter of cylinder 6¼ ins.,

stroke 8 ins., nominal horse-power 20, indicated horse-power, 50 to 55.

Messrs. G. Davis & Co., Abingdon. 1885.

139. DIRECT-ACTING CENTRIFUGAL PUMP AND STEAM ENGINE. Capacity 100 gallons per minute. Chiefly suited to circulating water through yacht engine condensers. It has two suctions, and by means of a stop valve can be set to pump out the bilge of the vessel.

Messrs. G. Davis & Co., Abingdon. 1885.

140. SCREW ENGINES. E. E. Wigzell's inverted cylinder screw engines for yachts, 6 in. diameter cylinders, stroke 7 ins. Fitted with David Joy's valve driving gear, 1879–1880.

Lent by Messrs. Timothy Bates & Co., 37, Walbrook, E.C. 1885.

Note.—Joy's slide valve driving gear, deriving its motion from the connecting-rod of the crank to the piston-rod, and doing away with the usual eccentrics and their attachments for driving the slide valves has become established for all clases of steam engines, whether working as stationary engines, locomotive engines, or marine engines.

141. SCREW LAUNCH ENGINE. Kingdon's compound surface condensing screw engine and boiler, fitted with Simpson and Denison's patent feed and air-pump.

Messrs. Simpson and Strickland, Dartmouth. 1885.

Note.—This working engine and boiler for small craft has features of note. The engine is a compound high and low pressure tandem cylinder engine, working with or without steam condensing arrangements. The boiler, a vertical upright tubular boiler, has a large circular top or head, giving much steam storage space.

142. SCREW ENGINES. Compound surface condensing engines, designed for yachts and line fishing vessels. Fitted with Chapman's patent combined air and feed pump and air extractor, and Young's patent piston.

Messrs. Hawthorns & Co., Leith, N.B. 1885.

Note.—The engines, full size, are especially designed for rough work. They represent two cylinder inverted compound condensing engines suited for screw propeller steam fishing vessels.

143. SCREW ENGINES. Cormack's inverted compound surface condensing screw engines. 6 indicated horse-power. Suitable for a 30 ft. launch.

Messrs. Hawthorns & Co., Leith, N.B. 1885.

Note.—This working engine for screw steam launches has an inverted cylinder, the slide valves of which are driven by a single eccentric fitted on Cormack's plan.

144. MOVABLE DIAGRAM in wood, of Cormack's slide valve driving gear.

Messrs. Hawthorns & Co., Leith, N.B. 1885.

145. PHOTOGRAPHS, TWO. Rankin's six-cylinder quadruple expansion disconnective engines, fitted to the screw yacht "RIONNAG-NA-MARA," by Rankin and Blackmore, Greenock, 1886. Steam at a pressure of 170 to 200 lb. per square inch is supplied by a steel boiler constructed on the ordinary return tubular principle.

Lent by Messrs. Rankin and Blackmore, Greenock. 1886.

Note.—The screw steam yacht "RIONNAG-NA-MARA," 170 × 20 × 13½ ft., 311 tons Thames yacht measurement, was built in 1886 by John Reid and Co., Port Glasgow. The engines are accounted highly satisfactory since running. They develop 528 indicated horse-power, and drive the yacht at a speed of 12 knots per hour. They have three high-pressure cylinders of 7 ins. diameter, and three expansion cylinders of increasing diameters. The stroke is 26 ins. The main shaft has three cranks, each of which is driven by a pair of the cylinders set up tandem fashion above the cranks.

146. PHOTOGRAPH. Rankin's four cylinder disconnective quadruple expansive engines fitted in 1887 to the screw yacht "MYRTLE."

Lent by Messrs. Rankin and Blackmore, Eagle Foundry, Greenock. 1887.

Note.—These engines have four cylinders of unequal diameters, but uniform stroke. They can be disconnected and run separately if required. The condenser lies at the back of the engines, together with the air, feed, bilge pumps, &c.

For other photographs of Rankin and Blackmore Engines, see pages 179, 192, 197.

147. SCREW ENGINES. Two-cylinder inverted compound surface-condensing engines for steam launches. Cylinders 5 and 10 ins. diameter, stroke 6 ins. In the bed-plate are annular passages making connexions between condenser, air pump, and circulating pump.

Mr. F. T. Harker, Stockton-on-Tees. 1885.

148. SCREW ENGINES. A small inverted single-cylinder engine for steam launches. The cylinder, standard, and bed-plate, are cast in one piece.

Mr. F. T. Harker, Stockton-on-Tees. 1885.

149. EIGHT PHOTOGRAPHS (in one frame). Inverted screw propeller engines.

Lent by Mr. F. T. Harker, Stockton-on-Tees. 1885.

Note.—The photographs illustrate various forms and types of modern compound system engines for driving either single or twin-screw propeller vessels of small size.

150. SCREW ENGINES. Full size double cylinder inverted direct-acting compound condensing screw engines for steam launches. Cylinders 7 ins. and 14 ins.; stroke 8 ins. Weight 18 cwt.

Mr. F. T. Harker, Stockton-on-Tees. 1886.

Note.—The connexions between the condenser and the pumps in these engines are carried through the bearings of the crank shaft on the engine bed plate, which are hollow and permit flow of water through them.

151. DRAWING on a scale of 1½ ins. to 1 ft. Triple expansion engines of the screw yacht "GLADIATOR," built 1886.

Lent by Messrs. Ramage and Ferguson, Leith. 1887.

Note.—The cylinders of the engines are 9¼ ins., 15 ins., and 24½ ins. diameter. Stroke 18 inches. Diameter of air and circulating pumps 9 inches; the feed and bilge pumps 2 ins., with a stroke of 9 ins. Condenser cooling surface 300 square feet. Working steam pressure at boiler 150 lbs. per square inch.

For boiler of steam yacht "Gladiator," see page 170.

152. PHOTOGRAPH. Compound, surface-condensing screw engines, with Bremme's slide valve driving gear, fitted to the Egyptian Government's coast guard yacht "SAREEA." Cylinders 10 ins. and 20 ins. diameter. Stroke 14 ins.

Presented by Messrs. Ross & Duncan, Whitefield Works, Govan, Glasgow. 1887.

Note.—The steam for the engines of the "SAREEA" is supplied by a steel-built double-furnace multitubular boiler, suited for a working pressure of 100 lbs. per square in. On the trial trip the true mean speed of the yacht was 11 miles per

hour, with the engines developing about 120 horse-power, and running 200 revolutions per minute.

For a photograph of the steam yacht "Sareea," see page 81.

For a model of R. Duncan's screw propeller, see page 246.

CLASS III.

Donkey Engines, Feed Pumps, Fittings.

MARINE BOILER FEED PUMPS.

154. STEAM DONKEY ENGINE and PUMP. Single-acting, for feeding steam boilers with water.

Lent by Messrs. Alexander Wilson & Co., Vauxhall Works, Wandsworth Road, S.W. 1871.

Note.—Diameter of steam cylinder 3¼ ins., stroke 4 ins. Diameter of pump 1⅞ ins. Will pump 460 gallons per hour, and feed a 30 horse-power steam boiler.

155. THREE MODELS, in brass, showing in section the arrangement of Giffard's injector for feeding steam boilers with water.

Messrs. Sharp, Stewart, and Co., Manchester, and Victoria Street, S.W. 1870.

1. Giffard's own injector in section.
2. Giffard's injector in section, with the adjustment of Messrs. Robinson and Gresham.
3. Giffard's injector in section, with Seller's adjustment.

156. DRAWING, on a scale of 6 ins. to 1 ft. An improved donkey steam engine and pump for feeding steam boilers with water.

Presented by Messrs. Alexander Chaplin & Co., Glasgow. 1874.

157. PHOTOGRAPH of a double-action steam pump and donkey engine for feeding steam boilers with water.

Presented by Mr. P. Brotherhood, Lambeth. 1874.

158. PHOTOGRAPH of a single-action steam pump and donkey engine for feeding steam boilers with water.

Presented by Mr. P. Brotherhood, Lambeth. 1874.

CLASS III.

Marine Engine and Boiler Accessories.

GAUGES AND OTHER OBJECTS.

160. *a.* PEARSON'S LUBRICATOR; for steam cylinders, and other working parts of machinery.

b. Mercury VACUUM GAUGE, for condensing steam engines.

c. THERMOMETER for measuring high temperatures.

d. Bourdon's STEAM-PRESSURE GAUGES, for high and low pressure boilers.

e. Bourdon's VACUUM GAUGES.

f. Schäffer's STEAM-PRESSURE GAUGES, for high and low pressure boilers.

g. Schäffer's VACUUM GAUGES, for condensing steam engines, &c.

h. Schäffer's HYDRAULIC PRESSURE GAUGES, with maximum indicators.

i. BLAST FURNACE GAUGE, mercury, indicating 6 lbs. pressure.

k. 7-FIGURE COUNTER, in section, for counting steam engine revolutions, and speeds of machinery.

Messrs. Schäffer and Budenberg, Manchester. 1874.

Note.—These may be found in the machinery and inventions section, together with other accessories.

161. SPECIMENS, full size. Steam cocks, steam boiler water gauges, water cocks, and others, with packings of asbestos.

Messrs. J. Dewrance & Company, 176, Great Dover Street, S. 1876.

Note.—This principle of making cocks and valves with a bearing of asbestos, which is indestructible by heat and most of the acids, instead of the usual metal surfaces which have to be ground together to make them tight, has stood the test of use.

Model of 1½ in. cast-iron cock all nickel plated.

Drawing, framed, of 3-in. cock.

Model of 3-in. cock, cast-iron, flanged.
Do. 2-in. do. do.
Do. 1¼-in. do. do.
Do. gun-metal shell and two cups.
Do. gun metal 1-in. cock.
Do. ¾-in. water gauge.
Do. ¾-in. do. three-way.
Do. nickel plated cast-iron plug.

162. SALINOMETER. How's. For measuring the quantity of sea salt in marine steam boilers.
Lent by Mr. T. O. Buss, Hatton Garden. 1874.

Note.—In using the Salinometer, the water drawn from the boiler should be at 200° Fahrenheit. The instrument is adjusted for this temperature. It is graduated from 0· to 4·32.

0· fresh water. 1·32 sea water, which contains 1 lb. of salt to 32 lb. of water. 2·32 indicates 2 lbs. of salt to 32 lbs. of water, and so on.

To keep a marine boiler clean, the water should not contain more than 2 lbs. of salt to 32 lbs. of water.

163. REVOLUTION INDICATOR, for indicating constantly the number of revolutions per minute made by steam engines and machinery. Designed by Mr. James Wimshurst. 1876.

Note.—This constant speed indicator is of early date. There are now many machines of this kind used for indicating the speed of machinery. Amongst them may be mentioned Weir's, 33, Abchurch Lane, E.C. The strophometer made by Elliot Brothers, Strand; Butler's Patent, J. and J. Butler, Belfast, and others.

164. WATER GAUGE GLASSES, for steam and other boilers. Mr. John Moncrieff, North British Glass Works, Perth. 1879.

165. SPEED COUNTER. A pocket speed counter for counting the velocity of moving machinery. A. Sainte's counter.
Lent by Mr. R. Applegarth, Abchurch Lane, E.C. 1879.

Note.—Handy speed counters are indispensable to engineers. The instrument can be instantly set to zero, and having a separate set of figures for forward and backward motions, the number of revolutions can be read off without making a subtraction sum. In addition to the steel bit usually employed to communicate the motion of an axle to the counter, a little boxwood wheel, a steel punch, and a silk thread are provided. The wheel is a tenth of a yard in circumference, and measures the forward motion of a pulley

band. The silk thread measures exactly the length of the pendulum, the oscillation of the punch attached to it beats a second and marks a minute accurately.

Note on Safety and other Valves.

From the days of the discovery of steam, its properties, and the generation of it in a boiler, some method had to be provided for automatically relieving the boiler of undue steam pressure. The plan devised was called the safety-valve, a name familiar to this day in connexion with boilers. Many forms of safety-valves have been constructed. Denis Papin, of Blois, France, brought out in 1695, in conjunction with his "Digester," a safety-valve still in use. It comprised a disc or plate, of brass usually, made to fit accurately a "seat" or orifice in communication with the steam generated in the boiler, and held down in place by a lever of the third order or kind weighted at one end by a given or determined pendant weight. The steam pressure overcoming the weight opposed to it, lifted the disc from its seat, the steam escaped or "blew-off" into the atmosphere and relieved the boiler. When the steam became below the pressure required to lift the weighted valve it closed or shut down into its seat again.

Safety valves are known by the following names: Ordinary or weighted lever safety-valves. Spring balance safety valves, used on the locomotive engine and its type of boilers, and on several classes of high-pressure small boilers. Dead-weight safety-valves, in which the weight presses directly on the valve disc itself with a "dead weight" pressure. Dead weight spring safety-valves, similar to the preceding in arrangement but using powerful springs instead of weights. These last can be "locked up" so that once adjusted they cannot be tampered with.

There exist too many types or forms of safety-valves to describe minutely in this place. Seatless safety valves by the late R. McIntyre, Leeds; J. Swift, Birmingham. Adam's safety-valves; Turnbull's safety-valves; with many others, can be found mentioned in existing works on steam boilers and their fittings.

Other valves, such as stop valves, steam valves, blow-off valves, drain valves, bilge valves, Kingston valves, and many more connected with marine engines, boilers, and steamship fitting, can be studied in standard works on steamships and marine engineering.

166. Drawings of Safety Valves of marine steam boilers, for lecture purposes.

Mr. J. F. Flannery, 9, Fenchurch Street, E.C. 1877.

Note.—The drawings relate exclusively to spring safety valves for marine boilers, and show in section the following different varieties:—

Diagram 1. Theoretical principles, normal pressure 60 lbs. per square inch.

Diagram 2. Adams' patent safety valve. Spring loaded valve. Arranged to blow off at 70 lbs. per square inch.

Diagram 4. Safety valves on the boilers of Chinese gun boats "Foo So," and others.

Diagram 5. Safety valves on the boilers of the Chinese steamships "KONG-GI" and "HI-YEI."

Diagram. Turton's patent compensated spring loaded safety valve. This valve is held in place by upright bars of various metals which "compensate" or equalize the pressure they maintain on the valve under the varying conditions of heat and cold to which they are liable in working.

Diagram. An ordinary spring safety valve in section.

167. DEAD-WEIGHT SAFETY VALVE, for boilers. Eaves' design.

Messrs. John Brown & Co., Limited, Sheffield. 1879.

Note.—The valve is formed by a perfect sphere seated on hardened steel. The frame carrying the valve weights is suspended by a concave centre-piece lined with soft metal protecting the valve sphere from injury, and allowing the weights to hang perfectly free and plumb.

STEAM AND OTHER VALVES.

168. STEAM VALVES. Holt's. Two gun-metal steam stop valves.

Lent by Mr. H. P. Holt. Leeds. 1879.

169. STEAM CYLINDER, DRAIN, and ESCAPE VALVE. Dawe's valve.

Lent by Mr. H. P. Holt. Leeds. 1879.

170. MODEL, in wood, illustrating Halpin's equilibrium slide valve for steam engines.

Lent by Mr. D. Halpin. London. 1879.

Note.—The model shows a horizontal steam cylinder, and the construction of Halpin's equilibrium slide.

171. SLIDE VALVE MOTION. Working model of Halpin's slide valve motion, for rapid cut-off and increased steam expansion.

Lent by Mr. D. Halpin. London. 1879.

172. DRAWINGS, TWO, on a scale of $\frac{3}{4}$ in. to 1 foot. Laing's single eccentric valve gear fitted to compound oscillating paddle-wheel engines.

Presented by Mr. Andrew Laing, the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow. 1887.

Note.—The engines represented in the drawings are fitted in the Zeeland Steamship Company's vessels running between Queenboro' and Flushing. They indicate 4,000 horse-power, the high-pressure cylinder is 60 ins. diameter and the low-pressure cylinder is 104 ins. diameter, stroke 7 ft., boiler steam pressure is 80 lbs. per square inch. Driving oscillating cylinder marine engine slide valves by single eccentrics and suitable link motion was also achieved in the early part of 1886 by Mr. Hall Brown, of the Hartlepool Engine Works.

Engine Governors.

176. Governor. Marine engine governor; for controlling marine engines. Dunlop's Pneumatic governor. Messrs. Cunliffe and Dunlop, Port Glasgow. 1879.

Note.—The action of this governor is as follows: An air chamber, usually placed at the stern end of the ship, is connected by a sea-cock with the sea, which entering compresses the air in the chamber to a pressure due to the height of the water outside. By means of an air pipe leading to the engine-room, this compressed air is conveyed to the second part of the apparatus. This comprises an air vessel having its lower part closed air-tight by an india-rubber diaphragm, held down by a spring adjustable by a screw and nut according to the draught of the ship. The rising and falling action of the ship controls the rise or fall of the diaphragm of india-rubber, which diaphragm again controls, by suitable arrangements, the cut-off or admission of steam to the engines through the throttle-valve or equilibrium valve, and so regulates their speed. This governor has been in use over seven years, both in H.M.'s ships of war and on board some of the largest commercial steamships.

177. Series of Models, in brass, of governors for land and marine steam engines, and other inventions. Thomas Silver, Philadelphia, U.S.A.
Transferred from the Patent Museum. 1885.

Note.—These governors, designed by Thomas Silver, of Philadelphia, 1855 to 1869, are intended principally for controlling the marine engines of screw steamships and preventing what is technically known as "racing." They were adopted for use by the British Admiralty in 1869. The models have been transferred to the scientific apparatus section of the Museum.

178. Model. Chronometric speed indicating governor for marine steam engines. J. Standfield's patent, 1861.
Transferred from the Patent Museum. 1885.

179. ENGINE GOVERNOR. Gyrometric.
Mr. Scott Moncrieff. London. 1876

Note.—In this governor the centrifugal force of a fluid is so applied as to regulate the aperture of a throttle-valve through the movements of a loaded piston. It consists of two chambers containing fluid, and communicating with each other through a turbine wheel with four or more straight radial arms. The speed of this wheel depends upon that of the prime mover by which it is driven, and the pressure in the front chamber is dependent upon its velocity, and its variations open and shut the throttle-valve.

NOTE ON STEAM ENGINE GOVERNORS.

There was exhibited at the Scientific Apparatus Exhibition, South Kensington, 1876, an improved form of steam engine governor by the late Dr. C. W. Siemens (1822–1883), namely, a gyrometric governor, the principle of which consisted of an open cup of parabolic shape, fixed upon a vertical spindle, and caused to revolve within a closed chamber containing a liquid, the bottom of the cup being open and always immersed below the surface of the liquid. When the cup is made to revolve rapidly, the liquid contained in it rises round the sides of the cup and sinks in the centre, the surface of the liquid assuming the inverted parabolic form; and on reaching the edge of the cup it overflows into the surrounding chamber, while at the same time a fresh supply of liquid is drawn into the cup through the opening in the bottom; and the power absorbed in putting the overflowing liquid into motion offers a continuous resistance to the rotation of the cup. On a level with the edge of the cup, a series of fixed vanes are placed around the circumference of the external chamber, and a corresponding set of blades are also fixed round the outside of the cup just below the rim, so that the sheet of liquid overflowing from the edge of the revolving cup is thrown against the vanes, and by these is thrown back against the blades on the cup, whereby the overflowing liquid is made to offer an additional resistance to the rotation of the cup. The internal radial arms uniting the shell of the cup to the centre boss serve to communicate the rotary motion to the liquid inside the cup, while the bottom of the external chamber is provided with a number of radial ribs, for the purpose of checking rotary motion in the liquid outside the cup.

So long as the cup is driven at a constant speed, the overflow is constant, and produces an absolutely constant resistance; and hence, if the cup be driven by a constant driving power, independent of the engine, its speed is as uniform as that of a chronometer, within a very small margin of variation, which is definitely fixed; and it continues revolving at an unchanging speed, totally independent of

the engine, and consequently affords the means of forming a governor for controlling the speed of the engine to a constantly uniform rate.

A governor or speed controller for steam engines was one of James Watts' (1736–1819) celebrated achievements connected with the steam engine. The governor is applied to all classes of engines required to run at uniform speed under varying loads put upon them. Similarly, by a governor or speed controller of some kind, are the large engines of steamships, particularly of screw propeller vessels, sometimes regulated as to their speed under the varying conditions of a steamship at sea.

CONDENSERS.

182. MCCARTER'S CONDENSER. Model.—Applicable to steam engines, and other purposes where a vacuum is required, effected by the condensation of steam, without the use of an air-pump, and capable also of drawing its own injection water.

Lent by Mr. James Wood, Burnley. 1876.

Note.—The condenser consists of two chambers, one above the other. The upper chamber (H) is for condensing the steam, the lower one (G), with the two tappet valves (C and D) opening into it, removes the condensed water from the upper chamber into the hot water cistern, whence it flows away. The exhaust steam from engine enters at A, meets the injection water entering at B, and is condensed, thus forming a vacuum, the water falling to the bottom of chamber (H). To remove this water, a vacuum is alternately created and destroyed, six times per minute only, in the lower chamber (G), by alternately raising the steam or water tappet valve (the steam supplying the tappet valve being reduced by reducing valve to 2½ lbs. pressure). On a vacuum being created in lower chamber, the water collected in upper chamber is drawn down through india-rubber foot valve (E); and on vacuum being destroyed in lower chamber, the water falls out through the delivering valve (F) into waste water cistern. A series of five lithographs of McCarter's Condensers lettered and numbered is exhibited. The references in this note refer to these lithographs.

The separate condenser with its appurtenances (jet condenser) was one of the many great and lasting inventions of James Watt, carried out by him in connexion with the steam engine.

Surface-condensers were patented 1831 by Mr. S. Hall, and applied to the engines of the paddle steamer "WILBERFORCE," 1838.

Accessories.

184. Lubricators for marine engines.
Messrs. Page and East, Harrison's Wharf, E. 1877.

Note.—These oil cups are used on board H.M. ships, and commercial steam vessels. They are self-acting, and are said to have produced a saving of 35 per cent. in tallow or other lubricating matter.

185. Steam Quieting Chamber. Designed by P. S. Justice.
Lent by Mr. G. Beck, 37, Devonshire Street, Queen Square, W.C. 1879.

Note.—The object aimed at by Mr. Justice in his invention of the steam quieting chamber is to overcome the roaring noise of the steam "blowing off" or escaping from the boilers of steamships, locomotive engines, and steam boilers in general.

186. Steam Trap. Sectional Model of Vaughan's water separator and self-acting ejector or steam trap, designed to draw off water and air from steam engines and other pipes.
Messrs. Vaughan & Sons, West Gorton, Manchester. 1886.

187. Model. Faull's metallic packing, for piston rods, pump rods, and all packing purposes.
Mr. E. M. B. Faull, Newport, Monmouth. 1879.

Note.—The metallic packing is made from D. P. Matthew's bronze; it has been applied to land and marine engines since 1878.

Blowing Machines.

192. Photograph. Root's. Blowing machine. For blowing furnaces of iron and metal works, smitheries, and steam boilers. Attached to a vertical steam engine for driving same.
Presented by Messrs. Thwaites, Brothers, Vulcan Iron Works, Bradford. 1873.

Note.—Root's blowing machine is an American invention. It is used in all branches of iron and metal manufacture, and wherever a forced air supply is required.

193. Working Model. Root's pressure blower.
Messrs. Thwaites, Brothers, Vulcan Iron Works, Bradford.
Purchased. 1876.

Note.—This working model of Root's blowing machine for furnaces has attached to it a mercurial gauge and scale, showing the constant pressure of the blast supplied by the blower.

194. SECTIONAL MODEL. Baker's blowing machine. The Savile Street Foundry Co., Sheffield. 1879.

Note.—Baker's blowing machine was brought out in England a few years ago. It is capable of maintaining a pressure blast, and will also serve for pumping purposes.

NOTE ON BLOWING MACHINES.

Blowing machines seem to have been first erected in Great Britain by Smeaton at the Carron Iron Works, N.B., in 1760. A large blowing machine equal to supplying air to 40 smiths' forge fires was erected about this time at Woolwich Dockyard.

The hot-air blast used for blowing iron smelting furnaces was invented by Mr. James Neilson, of Glasgow, in 1828. Mr. Neilson died in 1865. By this invention of the hot-air blast, *i.e.*, blowing machines driven by powerful steam engines and forcing hot or highly heated air into the metal smelting furnaces, a most important improvement in the production of iron was achieved, and a great economy gained in the consumption of the fuel used for smelting purposes. The hot-air blast is now of general adoption in all iron and metal smelting works.

The same principle of driving air into smelting furnaces by blowing machines, is adopted for urging the fires of marine steam boilers. There are three methods employed for the purpose. The first is simply forcing air into the stoke holds of steamships by fans or blowers so as to supply them with more air than can be got into the stoke holds by the natural or ordinary draught of the boiler furnaces. The second method is that of forcing air into the ashpits under the furnaces, the ashpits being closed up air-tight. The third method is closing up the stoke hold itself air-tight, and then forcing air into it so as to fill it with a higher pressure of air than is obtained by natural means. Each of the three systems is in vogue at the present time. The first is working in the mail steamers of the City of Dublin Company's vessels running between Holyhead and Kingstown, in the London and North-Western Railway Company's steamers on service between Holyhead and Dublin City; and the Zeeland Company's paddle steamers on the Queenborough and Flushing service; Messrs. Laird, Brothers, Birkenhead, and John Elder, & Co., Glasgow. The second system is represented by the forced draught arrangements in marine steam boilers of Messrs. Howden, Glasgow; Ferrando, Newcastle; Martin, London; Green,

London ; and others. The third has been sometimes used in swift torpedo boats of Imperial navies.

Yarrow & Co., Poplar ; J. I. Thornycroft, Chiswick ; J. & G. Thomson, Glasgow ; Sir W. G. Armstrong, Mitchell, & Co., Newcastle ; Palmers' Shipbuilding Co., Jarrow ; Earle's Shipbuilding Co., Hull ; Barrow-in-Furness Shipbuilding Co., Barrow in-Furness ; Hannah, Donald, and Wilson, Paisley ; and other shipbuilders and marine engineers, both abroad and at home, are constructors of torpedo vessels.

Another recent and novel boiler furnace system is L. Hopcraft's plan, 1886 (15, Queen Street, Queen Victoria Street, E.C.), comprising forced draught ; grate and bars circular, revolving and self-clearing ; mechanical and under-feed continuous stoking ; smoke-consuming, and burning slack or small coal. This system is working in the Thames River steamer "LOTUS," 1889.

HYDRAULIC ACCESSORIES.

Note.—Joseph Bramah, C.E., was the inventor of the hydraulic press, which bears his name. He was born in 1749 and died in 1814. Originally a French engineer of repute, Bramah settled in England and invented many other ingenious contrivances, amongst them the celebrated Bramah lock, constructed principally for the security of important documents, money, &c. in fire proof safes, for the use of bankers, merchants, and householders. The hydraulic press was invented in 1795.

196. PHOTOGRAPH of Pearn's double-action ram force and lift pump, with one ram attached to a direct-acting inverted cylinder steam engine.

Presented by Messrs. F. Pearn & Co., Hulme Hall Road, Hulme, Manchester. 1874.

197. PHOTOGRAPH of a 3-cylinder steam engine, attached to a 3-cylinder pump. P. Brotherhood's system, 1874.

Presented by Mr. P. Brotherhood, Lambeth. 1875.

198. MODEL. Centrifugal Pump.

Messrs. Lawrence and Porter, Engineers. 1876.

Note.—This pump has the feature of making one side of the casing removable. By taking off the movable side, the disc or "fan" can readily be examined or removed in a few minutes without interfering with the suction or delivery pipes.

199. HYDRAULIC LIFTING JACK. Ten-ton Jack.

Messrs. Tangye, Brothers, 35, Queen Victoria Street, E.C 1879.

Note.—These useful jacks constructed and working on the principles involved in Bramah's hydraulic press, 1795, are made in sizes for lifting three tons and upwards.

200. SCREW LIFTING and TRAVERSING JACK; on a bed-plate and framing of steel. Twelve-ton traversing bottle screw jack.

Messrs Tangye, Brothers, 35, Queen Victoria Street, E.C. 1879.

Note.—Lifting jacks working with a screw for raising and lowering heavy weights, as well as traversing either way at will, were the original invention of George England, 1839. At the present time lifting and traversing screw jacks are of universal application for engineering purposes.

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205. ENGINE ROOM and STEERING TELEGRAPHS.

Messrs. Chadburn & Son, Liverpool. 1879.

Note.—Telegraphs or indicators of officers' orders to engine-rooms and to helmsman are of much importance in large and powerful vessels. The instruments are constructed with a single indicating action merely, or with a repeating action by which the orders of the officers, on execution, are repeated back to them.

CLASS IV.

Modes of Propulsion.

Masts and Yards.—Rigging, Standing and Running.—Sails.—Mechanical Propellers.

Note on Masts and Rigging.

The masts of a ship, together with the rigging (standing and running), and her spread of sails to the wind, form elements of precise determination in the affairs of ship-building.

Since the enormous application of steam power and machinery to propel ships through the water, the question of their masting, and rigging, and sail power has gradually diminished in proportion to the increase of the application of mechanical methods of propulsion. Hence arises the recent development of mastless ships for certain purposes, and the decline of sailing ships pure and simple. Nevertheless, sailing ships, and steam ships capable of sailing or using sail power only to make head way, continue to be built and sent to sea.

Bouguer laid down in his "Traité du Navire," Liv. I., sec. II., cap VI., four general rules for determining the masting of ships. John Fincham, Master Shipwright at Portsmouth Dockyard, is also author of a treatise on masting ships.

Masts generally stand upright or vertical to the plane of the water line, but they are also set up with a "rake" or inclination backwards from the vertical towards the ship's after end. The masts of many light craft of foreign design and build are "stepped" or set up with a "rake" forwards.

There are also to be mentioned the yards, spars, &c., which, with other parts of the full rig, form questions of consideration in the outfit and stability of a ship.

The sails have likewise to be determined as to size, area, and weight, in connexion with the complex matters concerning the safety and efficiency of a comfortable, easy, and swift vessel, whether she is a sailing vessel or a steam vessel. In Vol. XIII. of the "Transactions of the Institution of Naval Architects" will be found useful particulars concerning masts, sails, and rig, contributed by Mr. J. G. Wildish.

Masts.

1. Model of the masts, rigging, and sails of H.M.'s ship "Ganges," 84 guns. (On ½-in. scale.) Length 196 ft. 5½ in., breadth 52 ft. 2½ in., tonnage 2,285. Laid down at Bombay in 1819, launched in 1821. Designed as "Canopus."
Presented by the late Captain Hugh Talbot Burgoyne, R.N. 1865.

2. Model of section of a vessel with masts and sails on the flat-surface principle.
Presented by Lieut. W. Congalton, R.N.R. 1865.

3. Two Models of vessels illustrating a new method of rigging ships with flat-surface sails.
Proposed and lent by Lieut. W. Congalton, R.N.R. 1865.

Note.—a. Model illustrating a merchant sailing ship, full rigged, of about 1,300 tons burthen. Rigged to show masts and flat surface sails on Lieut. Congalton's plan.

b. Model illustrating the rig for a screw steamship, "Chinese fashion," with flat surface sails on Lieut Congalton's plan.

4. Two Models of studding sails, with yards. 1864.

5. Model of Cunningham's self-reefing topsail, or plan for reefing from the deck. Invented by Henry D. P. Cunningham, 1850.
Lent by the late Mr. H. D. P. Cunningham. 1866.

6. Model, working of sails. The upper deck of a ship, showing two different arrangements of Cunningham's patent method for reefing topsails from the deck. The foretopsail and yard in the model is Cunningham's latest plan and arrangement, 1870. The main topsail and yard is the original plan of Mr. Cunningham, 1850.
Lent by the late Mr. H. D. P. Cunningham. 1871.

7. Model (same model as preceding) working of yards. The upper deck of a ship of three masts, fitted with Cunningham's patent chain gear and windlass, for hauling upon the braces of the lower yards, so as to square or brace them by one operation.
Lent by the late Mr. H. D. P. Cunningham. 1871.

8. Model of ship's deck, with three masts rigged, to illustrate Cunningham's patents for reefing topsails, &c. from the deck, in order to avoid sending men aloft.

H. D. P. Cunningham's patents, 1850, 1855, 1856, 1857, 1860, 1861.

Contributed 1863.

Transferred from the Patent Museum. 1885.

9. THREE MODELS of faggot-built masts, for line-of-battle ships.

Presented by Mr. J. S. Tucker. 1865.

10. MODEL of a patent topmast, designed by Captain Turnbull.

Presented by Messrs. Laurence Hill & Co., Glasgow. 1865.

11. MODEL. Four pieces painted; illustrating in wood Mr. R. Blake's plans for the construction and building up of the masts of a ship of war, and showing dispositions of cheeks and outside pieces. Proposed by Mr. R. Blake, Master Shipwright H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

12. MODEL of the mast of the Man-of-war "NELSON," in seven pieces, without the pieces which form the top.

Lent by Mr. James Young, West Docks, South Shields. 1876.

DIMENSIONS, WEIGHT, AND EXPENSE OF THE "NELSON'S" MAIN MAST.

	£	s.	d.
No. 1. Expense of seven trees	860	16	6
2. Hoops, bolts, and nails	61	11	6
3. Smith work	16	4	0
4. Mast makers	55	0	7¾
	993	12	7¾

	ft.	ins.
Length	127	2¼
Greatest diameter	0	41
Smallest diameter	0	30⅜

	Tons	cwt.	qrs.	lbs.
Weight	26	0	3	24

FITTINGS.

13. MODEL of "Blake's" single hook for futtock shrouds. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

14. Two Models (*a* and *b*) of "Blake's" patent fids and plans for fidding topmasts. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

Note.—One of these models (*b*) shows the fid plan adopted for the Royal Navy after trial on board H.M.S. "Queen," "S. Vincent," "Illustrious," "Warspite," "Vindictive," and others. 1807–1813.

15. Model of "Blake's" stoppers and fid for shortening the bowsprit. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806-1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

16. Model of "Blake's" tumbler hook for letting go the sheet of a boat's sail in cases of emergency. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

17. Two Models, one iron and one wood, for steps of lower masts, on "Blake's" plan. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

18. Model of "Blake's" plan, showing alteration in method of Securing Shrouds, and doing away with lower Deadeyes. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

19. "Blake's" proposed Deadeyes for all ships. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

20. Five plans (on "Blake's" principle) for Toggles. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

21. Screw Eye-bolt (on "Blake's" plan). Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

22. Model in iron of a ratchet and lever for setting up ship's shrouds. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by Rev. J. Hardie, Falmouth. 1866.

Blocks.

23. (*a.*) One common block, with hemp strop; (*b.*) one with iron sheave, and seasoned wire strop, by Mr. Andrew Smith; (*c.*) one iron bound block. 1864.

24. Common single block. 1864.

25. Two common unfinished blocks. 1864.

26. Two cheek blocks. 1864.

27. Bound block, with two side hooks. 1864.

28. Arnett & Co.'s patent roller sheave, for ship's blocks. 1864.

Rope.—Hemp and Fibre, Iron Wire.

29. Specimen of hemp rope. 1864.

30. Specimen of rope for hand and deep-sea lead. 1864.

31. Specimens of London made hempen and fibrous rope for ships' rigging, tackle, and cordage. "London staple."

Lent by Messrs. Frost, Brothers, Ropemakers, London Street, E.C. 1874.

Note.—The samples of hempen and fibrous rope exhibited by Frost Brothers, comprise the following descriptions :—

10 in. tarred hawser. Manilla hemp. Used generally in British vessels in preference to hawsers of other fibres.

8 in. white rope. Manilla hemp. Used for ships' hawsers by engineers and others.

9 in. four strand tarred rope. Russian hemp. Used for ships' standing rigging.

5½ in. four strand tarred rope. Russian hemp. Used for lanyards of large ships, and for yachts' rigging.

4½ in. cross spun tarred rope. Manilla hemp. A pliable rope and does not kink.

4½ in. cross spun white rope. Manilla hemp. A pliable rope and does not kink.

3 in. tarred rope. Manilla hemp. Used for ships' running gear.

3½ in. four strand cable; laid white rope. Manilla hemp. Used for dredging purposes.

3 in. four strand tarred rope. Russian hemp. Used for yachts' gear.

Deep sea sounding line. Italian hemp.

Sounding line. Italian hemp. Used chiefly in telegraph cable lying.

Lead line. Italian hemp.
15 thread log line. Italian hemp.
12 thread log line. Italian hemp.
Signal halyards. Italian hemp.
15 thread white hambroline. Italian hemp.
12 thread white hambroline. Italian hemp.
9 thread white hambroline. Italian hemp.
6 thread white hambroline. Italian hemp.
6 thread fine white hambroline. Italian hemp.
15 thread tarred hambroline. Russian hemp.
12 thread tarred hambroline. Russian hemp.
9 thread tarred hambroline. Russian hemp.
6 thread tarred hambroline. Russian hemp.
6 thread tarred hambroline. Russian hemp.

32. Rope and cordage for ships' use.
Messrs. T. and W. Smith, Newcastle. 1876.

Note.—Samples of iron wire rope for standing rigging, with dead eyes seized in and spliced in. Thimbles seized and spliced in. Heavy iron wire rope 4½ ins. in circumference. Hawser and rigging rope of Manilla hemp. Deep sea lead lines, log lines, signal halyards, house line, &c. Tarred rope, for lanyards, ratlines, wormed rigging, and tow ropes. Thimbles for lanyards; hanks for staysails; copper wire rope and points for lightning conductors; and other samples.

33. Specimens of galvanized iron wire and rope, with hearts for the same. 1864.

34. Specimens of iron wire rope, for standing rigging. 1864.

35. Specimens of iron wire rope. 1864.

36. Specimens of iron wire and copper wire rope for ships' rigging, lightning conductors, &c.
Messrs. Newall & Co., London and Gateshead. 1874.

37. PIECE of BOLT ROPE, with two pieces of canvas; used for parcelling. 1864.

38. SAMPLES of CANVAS used in the Royal Navy. Manufactured by Messrs. Baxter Brothers, Dens Works, Dundee, 1876.
Lent. 1877.

Note.—The samples of canvas comprise—Sail canvas Nos. 1 to 6. 40 yards in the piece. Hemp sacking for coals, Royal Navy. Hammocking, Royal Navy. Duck, Royal Navy. Flax sheeting, Royal Navy.

39. BLOCKS AND TACKLE. Ships' blocks, sheaves, bushes, thimbles, deadeyes, belaying pins, and other ships' tackle.

Mr. J. E. Dickinson, Liverpool. 1882.

OARS.

Note.—Oars and sweeps, the earliest known form of mechanical and manual application to the propulsion of ships, vessels, and boats, are not at the moment illustrated as a series in the ship model collection.

In 1879, however, actual full sized sweeps, oars, sculls, poles, boat-hooks, and such generic methods of and for propulsion were fairly well represented by loans from makers both of London and the provinces.

Sweeps, oars, sculls, paddles, &c., though so universally well known in connexion with both open sea and river navigation, naturally fall into the section of a ship model and marine engineering collection illustrating methods of ship and boat propulsion. Models to scale of these propellers it is hoped, may be hereafter obtained by loan or presentation, if full sized objects be not represented.

With respect to oars applied to the propulsion of boats and vessels, it may be interesting to record, that in 1783 to 1787 experiments were made in America by Mr. Fitch with shovels or paddles driven by a steam engine. These experiments took place apparently on Lake Collect, in the vicinity of New York.

NOTE ON MECHANICAL PROPELLERS.

Propellers used for driving ships are known as paddle-wheel and screw propellers.

PADDLE-WHEELS.

Paddle-wheels driven by steam power for the propulsion of ships, are of early date. In 1737, Jonathan Hull, an English engineer, designed a steamboat driven by paddles. Since this date innumerable improvements have been made in paddle-wheels, and they are now divided into two sorts.

The "paddle-wheel," in which the floats or dash-boards on the circumference of the wheel are rigidly fixed to its spokes or arms and periphery.

The "feathering-float wheel," in which the floats or dash-boards of the wheel are movable, and controlled as to their effective action on the water by means of long rods attached to them, which are governed by an arrangement of a wheel, called the eccentric wheel, revolving on an axle fixed out of the true centre of the paddle-wheel itself, The

arrangements cause the floats to enter and leave the water almost in a vertical direction edgewise, whilst at its deepest immersion the float is absolutely vertical. These feathering wheels were brought out by Elijah Galloway in 1829, and by William Morgan, 1839. The Messrs. Samuel and James Seaward improved them, 1837 to 1841. Mr. Maudslay again improved them in 1843 to 1846. In 1815, Mr. Charles Baird, an English engineer at St. Petersburgh, applied paddle-wheels with feathering floats to a steamboat which he fitted out to run on the river Neva.

The largest paddle-wheels are those of the "GREAT EASTERN" steamship, built 1857. They were 56 ft. in diameter, 13 ft. deep, and had 30 fixed paddle boards or floats each.

Two other kinds of paddle-wheels at one time in favour may be noted. The American wheel, devised about 1835–38, by Stevens of Hoboken, which comprised short and separate float boards fixed at varying positions across the paddle-wheel with clear spaces between the floats. The English "cycloidal" wheel, devised by Messrs. Maudslay and Field, and fitted in 1837 to the Atlantic voyage paddle-wheel steamship "GREAT WESTERN," had narrow float boards, two or more, fixed to it, with open spaces left longitudinally between them.

SCREW PROPELLERS.

The present universal means in use for the propulsion of ships, were first conceived and applied by numerous engineers in the early part of this century. The forms of the screw have been the subject of innumerable trials and many patents. The names of Bennet Woodcroft, 1826–1842; Sir Francis Pettit Smith, 1836; James Lowe, 1838; G. Rennie, 1839; H. Wimshurst, 1839; R. Griffiths, 1849; H. Hirsch, 1859; and Mrs. Henrietta Vansittart, 1868, are some of the better known names connected with screw propulsion.

The first steamship of war in H.M.'s Navy, built by the Admiralty and driven by the screw propeller was the "RATTLER." She was launched at Sheerness Dockyard in 1843 and broken up in 1856. She was designed by Sir Wm. Symonds. Tonnage 888. Guns 5. Nominal horse-power 200. After many trials and alterations her screw had only two blades or fans. This screw was cast in gun-metal: its weight 26 cwt. 2 qrs.; its diameter 10 ft. 1 in.; and its pitch 11 ft.

HYDRAULIC PROPELLERS.

Other means for propelling ships besides paddle-wheels and screws have been brought forward from time to time with more or less success on trial by inventors. Perhaps

the more successful of these plans is the system designed by Mr. D. Ruthven in 1843, improved by him in 1849, and finally practically developed and tried in 1866 on board H.M.'s iron-built ship "WATERWITCH," 162 ft. long, 32 ft. broad, and 11 ft. draught of water; tons 778; horse-power 160, nominal.

Mr. Ruthven's invention is known as "Ruthven's Hydraulic Propeller." It consists in the application of the turbine wheel driven by powerful steam engines to force water supplied to it through the ship's bottom with great energy, through and out of pipes running along ship's sides about her line of flotation. The water driven out by the turbine impinges with great force against the water outside, and propels the ship either way according to the direction in which the water is forced as controlled by suitable arrangement of water-way valves for the purpose.

In 1784 and 1793, Mr. Rumsey, in America, brings forward his plan for driving a boat, by using a steam engine to force water taken in at the bow out at the stern with great velocity. Dr. Franklin, U.S.A., took considerable interest in these trials.

PADDLE-WHEELS.

Note.—There are two principal descriptions of paddle-wheels in use:—

The wheel having "fixed floats."
The "feathering float" wheel.

In the former the floats or propelling boards, either of wood or iron, are rigidly fixed to the arms of the wheel.

In the feathering float wheel the floats are movable and "feather" as described in the note on propellers, page 222.

Plans have been tried from time to time to "reef" or draw inwards simultaneously, all the float-boards of an ordinary paddle-wheel with a view of overcoming the heavy thrust and lift of water experienced when the wheel is deeply immersed by the draught depth of water of the loaded steamer. As the vessel's draught varied, by the consumption of her coal store or other circumstances, the "reefed" floats would be pushed outwards simultaneously, and thus a beneficial action of the propelling float boards would be attainable.

It is necessary to "balance" the weight of the cranks of some kind of engines driving paddle-wheels. This is effected by placing iron floats on the wheels in the required positions.

The latest form of approved float for a feathering paddle-wheel appears to be the "curved float" (the floats being curved to a radius of half the diameter of the wheel) fitted 1884 by Mr. Stroudley to the steamers of the London and

Brighton Railway Company running between Newhaven and Dieppe, and designed and fitted also by Mr. A. C. Kirk for the Zeeland Company's paddle steamers on service between Queenborough and Flushing, 1877.

From the time of Thomas Savery, 1697, and Jonathan Hulls, 1736, more than 400 patents have been registered respecting improvements in paddle-wheels. Amongst which are noticeable, Patrick Miller, 1786–1787; John Morgan, 1812; Charles Baird, 1815; John Oldham, 1820; James Seaward, 1825–1841; E. Galloway, 1829; J. Spurgeon, 1837; Joshua Field, 1838; William Morgan, 1838; George Rennie, 1839; David Napier, 1841; J. J. Brunet, 1843; Henry Maudslay, 1843–1846; W. C. Golling, 1865; J. J. Aston, 1875; McLellan and Owen, 1882.

Paddle-wheel Models.

41. Model of a paddle-wheel with improved floats. Designed about 1850, by B. Woodcroft, F.R.S.
Lent by Mrs. B. Woodcroft. 1876.

42. Models. The feathering float paddle-wheels of the mail steamer "Leinster." Built 1860. Kingstown and Holyhead Mail Service. Scale 1½ ins. to 1 ft. Messrs. Ravenhill, Easton & Co., Engineers, London.

Note.—These paddle-wheels are attached to a model of the engines which drive them. *See* page 176.

43. Original Model. Vessel constructed by the late Bennet Woodcroft, F.R.S., for experiments on propulsion with paddle-wheels and screw propellers, 1832–1846.
Lent by Mrs. B. Woodcroft. 1876.

44. Paddle-wheels. Model of a paddle-wheel with feathering floats, designed and patented, 1829, by Elijah Galloway.
Contributed 1860.
Transferred from Patent Museum. 1885.

Note.—Galloway's invention appears to have been amongst the earliest patents secured for feathering the floats of paddle-wheels, as understood by the expression "feathering floats." The patent appears to have been purchased in 1838–9, by William Morgan, an engineer at the time at New Cross, and James Lancaster Lucena, his associate.

Galloway's wheel, therefore, would seem to have been really the original wheel known as Morgan's feathering float paddle-wheel.

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42. Models. The feathering float paddle-wheels of the mail steamer "Leinster." Built 1860. Kingstown and Holyhead Mail Service. Scale 1½ ins. to 1 ft. Messrs. Ravenhill, Easton & Co., Engineers, London.

Note.—These paddle-wheels are attached to a model of the engines which drive them. *See* page 176.

43. Original Model. Vessel constructed by the late Bennet Woodcroft, F.R.S., for experiments on propulsion with paddle-wheels and screw propellers, 1832–1846.
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44. Paddle-wheels. Model of a paddle-wheel with feathering floats, designed and patented, 1829, by Elijah Galloway.
Contributed 1860.
Transferred from Patent Museum. 1885.

Note.—Galloway's invention appears to have been amongst the earliest patents secured for feathering the floats of paddle-wheels, as understood by the expression "feathering floats." The patent appears to have been purchased in 1838–9, by William Morgan, an engineer at the time at New Cross, and James Lancaster Lucena, his associate.

Galloway's wheel, therefore, would seem to have been really the original wheel known as Morgan's feathering float paddle-wheel.

the more successful of these plans is the system designed by Mr. D. Ruthven in 1843, improved by him in 1849, and finally practically developed and tried in 1866 on board H.M.'s iron-built ship "WATERWITCH," 162 ft. long, 32 ft. broad, and 11 ft. draught of water; tons 778; horse-power 160, nominal.

Mr. Ruthven's invention is known as "Ruthven's Hydraulic Propeller." It consists in the application of the turbine wheel driven by powerful steam engines to force water supplied to it through the ship's bottom with great energy, through and out of pipes running along ship's sides about her line of flotation. The water driven out by the turbine impinges with great force against the water outside, and propels the ship either way according to the direction in which the water is forced as controlled by suitable arrangement of water-way valves for the purpose.

In 1784 and 1793, Mr. Rumsey, in America, brings forward his plan for driving a boat, by using a steam engine to force water taken in at the bow out at the stern with great velocity. Dr. Franklin, U.S.A., took considerable interest in these trials.

PADDLE-WHEELS.

Note.—There are two principal descriptions of paddle-wheels in use:—

The wheel having "fixed floats."
The "feathering float" wheel.

In the former the floats or propelling boards, either of wood or iron, are rigidly fixed to the arms of the wheel.

In the feathering float wheel the floats are movable and "feather" as described in the note on propellers, page 222.

Plans have been tried from time to time to "reef" or draw inwards simultaneously, all the float-boards of an ordinary paddle-wheel with a view of overcoming the heavy thrust and lift of water experienced when the wheel is deeply immersed by the draught depth of water of the loaded steamer. As the vessel's draught varied, by the consumption of her coal store or other circumstances, the "reefed" floats would be pushed outwards simultaneously, and thus a beneficial action of the propelling float boards would be attainable.

It is necessary to "balance" the weight of the cranks of some kind of engines driving paddle-wheels. This is effected by placing iron floats on the wheels in the required positions.

The latest form of approved float for a feathering paddle-wheel appears to be the "curved float" (the floats being curved to a radius of half the diameter of the wheel) fitted 1884 by Mr. Stroudley to the steamers of the London and

Brighton Railway Company running between Newhaven and Dieppe, and designed and fitted also by Mr. A. C. Kirk for the Zeeland Company's paddle steamers on service between Queenborough and Flushing, 1877.

From the time of Thomas Savery, 1697, and Jonathan Hulls, 1736, more than 400 patents have been registered respecting improvements in paddle-wheels. Amongst which are noticeable, Patrick Miller, 1786–1787; John Morgan, 1812; Charles Baird, 1815; John Oldham, 1820; James Seaward, 1825–1841; E. Galloway, 1829; J. Spurgeon, 1837; Joshua Field, 1838; William Morgan, 1838; George Rennie, 1839; David Napier, 1841; J. J. Brunet, 1843; Henry Maudslay, 1843–1846; W. C. Golling, 1865; J. J. Aston, 1875; McLellan and Owen, 1882.

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45. Paddle-wheels. MODEL of a paddle apparatus for propelling vessels. Patented, 1837, by John Spurgin.

Contributed 1857.
Transferred from Patent Museum. 1885.

Note.—This patent was obtained for the application of flat endless chains with long links running over two or more riggers, and driven by a toothed wheel placed centrally between the riggers and driven by a steam engine. To the endless chains Spurgin attached paddles or float boards, and by the apparatus proposed to gain increased efficiency in propelling vessels or boats specially of light draught. The model was lent in 1857 by the Commissioners of the Great Exhibition of 1851.

46. Paddle-wheels. MODEL, feathering float paddle-wheel. Patented, 1838, by William Morgan.

Contributed 1861.
Transferred from Patent Museum. 1885.

Note.—This wheel, Morgan's feathering float paddle-wheel, caused so marked an improvement in the efficiency of paddle-wheels that the feathering float system was speedily adopted for steamers of the naval and mercantile services; and it is in vogue to the present time for propelling high speed, short voyage paddle steamers. The "feather" of the floats is caused by the revolution of a wheel set on a separate axle excentric to the centre of the axle of the main wheel. To the excentric wheel by means of iron bars or rods the central depth of the float boards is attached; the boards are hung to the arms of the main wheel on spindles. The spindles have attached to them (usually at one end) arms or cranks to which the bars or connecting rods from the excentric are fixed. On turning the whole arrangement the paddles or floats will feather.

47. Paddle-wheels. FOUR MODELS, in wood. Fixed float-wheels. Patented 1839 by George Rennie.

Contributed 1857.
Transferred from Patent Museum. 1885.

Note.—These models represent several forms of improved float boards for paddle-wheels proposed by George Rennie, 1839, some of which were tried. The patent was taken out for float boards of paddle-wheels having a trapezoidal form, whereby the thrust and lift of rectangular floats were considerably modified. The floats are known as the "ducks foot" and the "lozenge" float. At same date Rennie secures a patent for a screw propeller having "leaves" or "plyers" of a curvilinean form attached round a shaft. Rennie calls this a conoidal screw propeller.

48. Paddle-wheels. WHOLE MODEL of a steam vessel fitted with George Rennie's trapezoidal float paddle-wheels. Patented 1839.

Contributed 1857.

Transferred from the Patent Museum. 1885.

49. Paddle-wheels. MODEL of part of vessel, fitted with inboard paddle-wheels. G. Bodmer's patents, 1841, 1843, 1844.

Contributed 1858.

Transferred from the Patent Museum. 1885.

Note.—The paddle-wheels were intended to work inside and not outside the ship, or between double hulls.

50. Paddle-wheels. MODEL of a paddle-wheel with reefing floats. Patented 1843 by J. Brunet.

Contributed 1860.

Transferred from Patent Museum. 1885.

Note.—This patent was obtained in 1843 for reefing simultaneously the float boards of paddle-wheels by mechanical means. The float board is divided, it will be seen, longitudinally, one half being before the wheel arm, the other half being behind it. The split or divided float was held in esteem for some years. The reefing or drawing inwards towards the wheel centre all the floats simultaneously and thrusting them outwards again on occasion, Brunet claimed as advantageous to steamers at their deepest draught when ready for a sea voyage and when by consumption of coal and stores their draught became gradually less and less.

51. Paddle-wheels. SEGMENTAL MODEL of a paddle-wheel with reefing floats. Patented 1843 by J. J. Brunet.

Contributed 1866.

Transferred from the Patent Museum. 1885.

Note.—The model represents a modification of the plan for reefing the floats, illustrated in the preceding whole model of Brunet's reefing float paddle-wheel.

52. Paddle-wheels. MODEL. A pair of paddle-wheels with feathering floats. Patented 1860 by Richard Vine.

Contributed 1862.

Transferred from Patent Museum. 1885.

Note.—This invention applies to self-acting transverse paddle-wheel floats for propelling steam vessels without any backwater. The floats turn on a spindle, and partly by weight and partly by the action of the water upon them they were to enter and leave the water always edgeways on, as it were, and during their deepest immersion were to act on the water full face or full area on.

53. Paddle wheels. MODEL. A pair of paddle-wheels with feathering floats. Patented 1860 by Richard Vine.
Contributed 1862.
Transferred from Patent Museum. 1885.

Note.—This model represents a pair of paddle-wheels of Vine's design, apparently an improved form of the wheels represented by the preceding model.

54. Paddle-wheels. MODEL of a paddle-wheel with counterpoised floats. Patented 1861 by William Tipple.
Transferred from Patent Museum. 1885.

Note.—The float board or paddle in this wheel is of iron, and is hung loose on a spindle running across the wheel in the usual way. The floats are free to turn on their own axes, and are so hung and weighted as to be kept vertical or upright after entering the water, during their passage through it, and when quitting it.

55. Paddle-wheels. MODEL of a fixed float paddle-wheel. Patented 1862 by William Henry Muntz.
Contributed 1862.
Transferred from the Patent Museum. 1885.

Note.—The floats of the wheel in this patent are set up vertically against the spokes or arms of the paddle-wheel instead of horizontally across them, in the ordinary way. The float boards have the shape of an oar blade, rounded it may be at both top and bottom ends, or otherwise, tapered off at the top end and rounded at the bottom end only.

56. Paddle-wheel. MODEL. Feathering float paddle-wheel. Patented 1865 by William Cantrill Gollings.
Presented 1873.
Transferred from Patent Museum. 1885.

Note.—This patent claims the application of an additional wheel fixed on the outside beam or sponson of the paddle-box, with its axle above or below the main axle of the paddle-wheel. The paddles are "feathered," kept perpendicular by means of a small crank connecting each float board with the additional wheel, which, being excentric to the axle of the paddle-wheel, feathers the floats or paddles in their revolution.

57. Paddle-wheels. MODEL of a paddle-wheel for canal steamboats. Patented about 1883 by McLennan and Owen.
Messrs. McLennan and Owen. 1883.

Note.—This wheel proposed to decrease the usual wash ashore of the water set in motion by an ordinary paddle-wheel.

58. Paddle-wheels. MODEL of a feathering float paddle-wheel. Inventor not known.

Transferred from Patent Museum. 1885.

Note.—The model of this wheel is of brass. The wheel bears strong resemblance to one of Samuel or John Seaward's feathering float-wheels, 1837–1846. The floats are feathered by the following method. Each float turns on an horizontal spindle to which it is fixed. A crank or crook at one end of the spindle is fixed to the periphery of a wheel placed on an axle or shaft excentric to the main wheel shaft or axle. The floats are feathered or controlled by the excentric wheel in the model turning on an axle above the centre of the main paddle-shaft and secured to the outside sponson of the paddle-box. The plan is similar to Golling's wheel, but the detail is more complex.

59. Paddle-wheels. MODEL of a feathering float paddle-wheel. Inventor R. Sheward.

Contributed 1866.

Transferred from the Patent Museum. 1885.

Note.—This model bears a similarity to the feathering float paddle-wheel of David Napier of Millwall, 1841. Napier took out a patent for feathering the float boards of paddle-wheels by means of a heavy iron ring without an axle hung to the floats by and to short cranks or levers on one or other end of the spindles of the float boards. The weight or gravity of the iron ring tending always downwards caused the floats to keep themselves constantly vertical or upright in their revolution. Napier's wheel was successfully applied to two celebrated iron-built steamers on the Thames, driven by "steeple" engines and haystack boilers devised by Napier, the "ECLIPSE" and "ISLE OF THANET," running from London to Margate. 1844.

60. Paddle-wheels. MODEL of a compound paddle-wheel. Inventor not known.

Contributed 1870.

Transferred from Patent Museum. 1885.

Note.—In this wheel, called a compound revolving paddle-wheel, the main wheel has on one side an inside rack running round its periphery, on spindles laid across the main wheel in the usual way, are a series of six revolving small wheels driven by a pinion gearing into the rack already mentioned. These small wheels again each have six float boards. When the main wheel is turned the six smaller wheels with their six floats revolve rapidly on their own axes or spindles, whilst the main wheel carries round with it the whole arrangement. This model was deposited in the Patent Museum in 1870 by the late Mr. William Smith.

61. Paddle-wheels. MODEL of a light paddle-wheel with four fixed floats. Inventor not known.

Contributed 1861.

Transferred from Patent Museum. 1885.

Note.—This wheel is exceedingly light in construction, and was probably so devised for service in shallow river or canal steamboats. The floats are fixed to the wheel spokes, and are stiffened by stays secured to the rim of the main wheel which has a single periphery only and four main arms or spokes from the axle to maintain it.

62. Paddle-wheels. WOODEN MODEL of a paddle-wheel with oblique floats. Inventor not known.

Contributed 1861.

Transferred from the Patent Museum. 1885.

Note.—Paddle-wheels having oblique fixed floats are patented frequently from the time of Joseph Bramah, 1785, till recent times. This model most nearly approaches the oblique float wheel of Samuel Hall, patented 1836. Similar wheels were devised by F. W. Stevens, 1839, and Samuel Perkes, 1852. The model represents two wheels set on a shaft having vertical arms which form relatively an angle of about 45°. The float boards are fixed diagonally across the width between the two wheels to their relative spokes or arms and thus beccme oblique floats.

63. Paddle-wheels. WOODEN MODEL of a paddle-wheel with floats revolving on upright or vertical spindles Inventor not known.

Contributed 1861.

Transferred from Patent Museum 1885.

Note.—This wheel, a single wheel, has heavy arms and periphery. The floats turn on a vertical spindle or axis, each one separately. There is a fixed cam or guide bolted on to inside or outside sponson of paddle-box. The cam controls the action of two sets of lugs or studs on the vertical axles or spindles of the floats. In the revolution of the wheel the action is that the lowermost float enters the water obliquely, or edge on, and is then immediately turned full face on. Having done its work whilst immersed, the float is again turned aside and quits the water edgeways similarly as on entering it. A paddle-wheel of similar construction was patented in 1858 by E. and T. Collingwood.

SCREW PROPELLERS.

Note.—In 1681, Dr. Robert Hook, 1635–1702, proposed the screw as a propeller applicable to driving boats and ships

through the water. The invention, however, though practically illustrated by Dr. Hook as efficient, died with its inventor.

In 1727 to 1768 experiments with the screw propeller were carried out in France.

In 1785 Joseph Bramah patented his invention, a screw propeller for ships.

In 1796–7, in America, experiments were carried out by Mr. Fitch of New York, with a screw propeller driven at the stern of a boat by a steam engine. Later by Mr. J. Stevens of Hoboken, 1804.

From 1790 to the present day innumerable inventions and patents figure in connexion with the history and development of the screw invented by Archimedes, B.C. 287; and the application of it as a propeller for steamships.

Screw propellers are of great variety. Some have been made with two, three, or even four complete turns about their axis. Others with one turn only. Others with multiple separate blades or fans.

Screw propellers are also devised and known as, increasing pitch screw propellers, varying pitch screw propellers, feathering blade screw propellers for altering at will the pitch of the screw to suit the varying conditions of the vessel propelled by it, cycloidal screw propellers, and others.

Much information on the rise of the screw propeller for ship propulsion will be found in the late John Bourne's book, 1852, and subsequently, "Treatise on the Screw Propeller."

Screw Propeller Models.

65. Model (unfinished) of a ship with a peculiarly made screw propeller, having three fans or blades, and showing method for securing the screw blades in their proper and relative positions. 1846.
The Admiralty. 1864.

66. Model, No. 1. Fothergill's self-feathering screw propeller. Adapted for auxiliary and small screw vessels.
Designed to obviate the necessity of raising the screw when under sail about 1865.
Lent by the late Rev. P. A. Fothergill. 1871.

67. Model, No. 2. Fothergill's self-feathering screw propeller. Adapted for auxiliary and small screw vessels. Designed to obviate the necessity of raising the screw when under sail. The screw is entirely self-acting and requires

no internal gearing. It can be set to any pitch, and used with any number of blades. 1865.

Lent by the late Rev. P. A. Fothergill. 1871.

68. MODEL of a double boat fitted with a screw propeller forward, to be driven by manual power. Tried in the Sussex river Ouse, 1823. The boat only attained a small rate of speed.

Lent by Mr. Burwood Godlee. 1872.

69. THREE MODELS, showing the original design of the after bodies of the first screw steamers, "ARCHIMEDES," built 1839; and "NOVELTY," built 1839–40.

The models show the forms of the original submerged screw propellers as fitted to the two ships, and modifications. The "NOVELTY" ultimately was driven by direct-acting engines, and two-bladed screw.

Lent by Mr. H. Wimshurst. 1873.

Note.—The dimensions of the ship "ARCHIMEDES" were,—extreme length 125 ft., extreme breadth 22 ft. 6 ins., depth 13 ft., tons 240. The engines were of 80 horse-power, nominal. The diameter of the screw 6 ft. 9 ins., length of screw 5 ft. It was driven by vertical engines and multiplied wheel gearing.

70. WHOLE MODEL of an armour-plated frigate, illustrating the late Mr. R. Griffith's proposals for improved screw propulsion. The ship is fitted with a bow and stern screw propeller placed well under the ship, and working in circular tunnels.

Lent by Mr. W. J. Griffiths. 1874.

Note.—The chief objects desired by this system for ship propulsion are:—Increase of speed, and economy of fuel. Protection to the screws. No vibration from the propellers. Reduction in size of engines and screws. Increased facility for manœuvring the vessel. In case of disablement to either screw, propelling power is available from the other. Proposed by the late Mr. R. Griffiths in 1872.

71. MODEL, in gun metal. A screw propeller on the late Mr. James Lowe's principle for the blades. 1838.

Presented by Mrs. Henrietta Vansittart. 1874.

72. WHOLE MODEL of steamboat "JAMES LOWE," fitted in 1838 with a screw propeller, under a patent granted to late Mr. James Lowe, in March 1838, for submerged propellers.

Presented by Mrs. Henrietta Vansittart. 1874.

Note.—About the same time a large boat called the "WIZARD" was fitted with a screw or submerged propeller, under the late Mr. J. Lowe's patent.

73. MODEL of the stern of a ship, fitted in March 1838 with a screw propeller, having one or more curved blades; sections or portions of a screw, of uniform or increasing pitch. Placed below the water-line of the ship.
Designed by the late Mr. James Lowe, 1838.
Presented by Mrs. Henrietta Vansittart. 1874.

74. WHOLE MODEL of the steamship "GREAT BRITAIN," fitted on the late Mr. James Lowe's plan for submerged or screw propellers.
Presented by Mrs. Henrietta Vansittart. 1874.

75. MODEL, in wood, of the first shaft and boss made for screw propellers, by late Mr. James Lowe, 1838.
Presented by Mrs. Henrietta Vansittart. 1874.

76. MODEL, in wood, of the first spherical boss for screw propellers, made by Mr. James Lowe, 1852.
Presented by Mrs. Henrietta Vansittart. 1874.

77. MODEL, in wood, of the first oval boss for screw propellers, made by Mr. James Lowe, 1855.
Presented by Mrs. Henrietta Vansittart. 1874.

78. MODEL, in wood, ¼ full size. The "Lowe-Van-" sittart" screw propeller blades.
Designed and fitted in 1869, by Mrs. Henrietta Vansittart, for trial on board H.M.S. "DRUID," 350 horse-power.
Presented by Mrs. Henrietta Vansittart. 1874.

79. DIAGRAM. of the original designs for submerged propellers and their blades, "Lowe's steamship propellers." Patented 24th March 1838 by Mr. James Lowe. This diagram shows various proposals for the forms of blades of screw propellers.
Presented by Mrs. Henrietta Vansittart. 1874.

80. DIAGRAM, illustrating Mr. James Lowe's proposals in 1855, for dividing the blades of screw propellers, and placing them in pairs or sets, diagonally across the screw boss. Tried on board H.M.S. "BULLFINCH," in 1857.
Presented by Mrs. Henrietta Vansittart. 1874.

81. DIAGRAM of Mr. J. Lowe's fourth improvement in screw propellers. 1862.
Presented by Mrs. Henrietta Vansittart. 1874.

Note.—This alteration consists in causing the blades of the screw propeller to form a curved line curling in opposite directions from the centre of the back and leading side of the blade to the edges. The drawing also shows the method of fixing the blades to the screw boss. This propeller was further improved by Mrs. H. Vansittart in 1868.

82. DIAGRAM of the modifications proposed in the "Wyche-Lowe" screw propeller blades.
Designed in 1852 by the late Mr. James Lowe, and tried on board the steamships "MISKIN" and "ARGUS." Also the "Lowe-Harris" screw propeller. 1862.

Presented by Mrs. Henrietta Vansittart. 1874.

83. DIAGRAM of a screw propeller and its blades.
Designed by Mrs. Henrietta Vansittart in 1868. Tried on board the "Allan" line steamship "SCANDINAVIAN," 400 horse-power, in 1873; and H.M.S. "CADMUS," 21 guns, 400 horse-power, in 1869, known as the "Lowe-Vansittart" screw propeller.

Presented by Mrs. Henrietta Vansittart. 1874.

Note.—The Lowe-Vansittart propeller on trial on board H.M.S. "DRUID" in 1869 has been found to possess, it is stated, full backing power, a total absence of vibration and to give an increased speed upon a reduced consumption of fuel. The propeller has considerable power in stopping ship's way, and affords great facilities for steerage.

The Lowe-Vansittart propeller has been fitted to many ocean-going steamships belonging to most of the principal steam navigation companies of the country, as well as to several of H.M.'s ships of the Royal Navy.

84. SCREW PROPELLER. Three-bladed screw propeller for steam launches. Diameter 22 ins. Pitch 2 ft. 6 ins.

Messrs. A. Verey & Co., Dover. 1875.

85. WORKING MODEL, in brass. Griffiths' patent feathering screw propeller. Mr. R. Griffiths. 1850.

Lent by Mr. W. J. Griffiths. 1875.

Note.—This model represents a two-blade Griffiths' screw propeller with central boss, and has screw gearing attached to it by which the pitch of the blades can be altered at pleasure from in-board.

86. BLOCK MODEL of a frigate prepared by the late William Laird, in 1836, to show application of the screw propeller to ships of war or vessels of large size,

Messrs. Laird Brothers, Birkenhead. 1876.

87. MODEL, in brass, of the screw propeller designed by the late Mr. G. Rennie, about 1840.

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

Note.—This screw was tried in 1843 in H.M.S. "DWARF," and drove the vessel at a speed of 12 miles per hour. The "DWARF" was built of iron, and was the first screw steamship belonging to H.M.'s Navy. She was originally called the "MERMAID." In 1839 George Rennie patents his conoidal screw propeller.

88. DRAWING. The original screw propeller; designed by the late Mr. G. Rennie, about 1843, and tried in H.M.'s iron ship "DWARF."

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars. 1876.

89. THREE MODELS, in wood; showing the forms from which the blades of screw propellers are obtained. The late Mr. Bennet Woodcroft, F.R.S. (1803–1879.)

Lent by Mrs. B. Woodcroft. 1876.

Model A. is a disc projecting from a shaft. If the blade or white portion on the disc (a sector deprived of the part nearest the apex or point where the two radial sides meet) be cut from the disc, and placed at an angle upon a shaft or axis, an inclined plane propeller is produced.

Model B. is a uniform pitch screw, the white part or blade cut from this screw and fixed on a shaft is the ordinary screw propeller.

Model C. By cutting the white portion of this model, and placing it on a shaft, the increasing pitch propeller is obtained.

90. MODEL, in wood. An increasing pitch screw propeller. Designed by the late Mr. Bennet Woodcroft, 1832–1846.

Lent by Mrs. B. Woodcroft. 1876.

Note.—The peculiar form of this propeller may be explained as follows:—

A spiral worm or screw is coiled round a shaft or cylinder in such form that the angle of inclination which the worm makes with the axis of the cylinder continually decreases, and the pitch or distance between the coils or revolutions of the spiral continually increases throughout the entire length of the shaft or cylinder upon which the spiral is formed. By thus progressively elongating the pitch of the screw, each successive part of it in its revolution begins to act before it is overtaken by the current given to the water by the preceding part of the screw, and consequently every part meets resistance from the water and thereby gains propelling power.

91. MODEL, in wood; patent feathering screw propeller. Two blades. Designed by the late Mr. B. Woodcroft, F.R.S., about 1844.

Lent by Mrs. B. Woodcroft. 1876.

Note.—This little model shows an early proposal, about 1844, by Mr. Woodcroft for feathering or varying at pleasure the angle of the blades of the screw propeller in relation to their shaft or axis, by means of mechanical arrangements for the purpose.

92. MODELS, in wood; showing various curves of screws for propellers.

Lent by Mrs. B. Woodcroft. 1876.

Note.—These are two models representing various forms of curves and variable form of screws. One of the models shows three screws of various curves. The other shows four screws of increasing pitch geared together, by which means the forms of the curves in relation to each other when the screw revolves are clearly discernible and produce a remarkable effect.

93. MODEL. To show difference of inclination in screw threads of the same pitch; traced on cylinders of different diameters.

Lent by Mrs. B. Woodcroft. 1876.

Note.—In this model the three wooden cylinders or rollers are covered with paper, and the screw threads are shown by blue lines traced on the paper around the rollers.

Two of the rollers are geared together to move at uniform speed, whilst the top roller revolves merely by the friction of the under ones when in action.

94. THREE MODELS; sterns of vessels fitted with varying pitch screw propellers. Woodcroft's patents, 1832, 1838, 1844, 1846.

Lent by Mrs. B. Woodcroft. 1876.

Note.—With one of these models is exhibited a single blade of the screw propeller, showing its isolated form. The three models together show the sterns of vessels fitted with varying pitch screw propellers, the peculiarities of which are detailed in the notes to the three following items.

1. MODEL. A varying pitch screw propeller, 1844, on shaft, in brass. (Fitted to the stern of a vessel).

Lent by Mrs. B. Woodcroft. 1876.

Note.—The first varying pitch screw propeller ever made was designed and patented by Mr. B. Woodcroft in 1844. In this description of screw propeller the blades, instead of being fixed to the shaft, are movable, and are combined with

suitable apparatus, whereby the angle which the blades form with their shaft or axis can be altered from a less to a greater or greater to a less degree, in order to obtain the best pitch for driving a vessel under varying circumstances.

In 1845 a varying pitch screw propeller was submitted to the Admiralty, and in 1846 a full-size screw was made of gun metal by Sir Joseph Whitworth, Manchester, for H.M.S. "DWARF." The screw was 5 ft. 8 in. in diameter, and the angle which the two blades of it will form with the shaft may be altered so as to give a variable pitch ranging from $4\frac{3}{4}$ ft. to $10\frac{3}{4}$ ft.

2. MODEL. A varying pitch screw propeller in brass on shaft; 1844. (Fitted to the stern of a vessel.)

Lent by Mrs. B. Woodcroft. 1876.

Note.—The blades of this screw propeller (two in number) are cut with an increasing pitch. Screw propellers having blades of uniform pitch are constructed on plans for varying the angle at pleasure which the blades form with their axis or shaft. Hence a screw propeller whose blades are cut on any form of pitch, if they can be altered at pleasure to form different angles with their axis, are called "Varying Pitch "Screw Propellers." This capacity for varying the pitch is in practice found useful for ship propulsion under the varying circumstances of long voyages or continuous cruising.

3. MODEL. Varying pitch screw propeller, in brass. Designed and patented by the late Mr. Bennet Woodcroft. 1844. (Fitted to the stern of a vessel.)

Lent by Mrs. B. Woodcroft. 1876.

Note.—This propeller has four blades instead of two, and the apparatus for turning the blades in order to change the angle or pitch is combined with an indicator which shows the angle at which the blades are set in relation to their axis or shaft. In ocean-going screw steamships the blades of a varying pitch screw are usually capable of being turned, and set in such a manner that their edges will stand nearly parallel to the centre line of the propeller shaft, or their faces will be almost in line with the ship's keel or run, and so offer little resistance to the vessel's way through the water when she is proceeding under sail only.

95. MODEL, of a ship. Constructed by the late Mr. B. Woodcroft for experiments in propulsion with paddle-wheels and screw propellers. 1832–1846.

Lent by Mrs. B. Woodcroft. 1876.

Note.—This model was constructed by Mr. B. Woodcroft for researches in the relative value of propulsion of ships by paddle-wheels and screw propellers, under uniform and varying circumstances.

96. MODEL, in wood. A double screw propeller. Designed and patented by the late Sir Francis Pettit Smith in 1836.

Lent by Mrs. B. Woodcroft. 1876.

97. MODEL. The after part of a vessel fitted with a screw propeller. Designed by the late Sir Francis Pettit Smith. 1836.

Lent by Mrs. B. Woodcroft. 1876.

Note.—The propeller consists of two whole turns of a screw thread round its shaft, and is placed in the dead wood or run of the vessel, but by a memorandum of alteration the patentee limits himself to a screw of one turn or two half turns.

98. SKELETON MODEL. The after part of a vessel fitted with a screw propeller. Charles Commerow's patent, 1828.

Lent by Mrs. B. Woodcroft. 1876.

Note.—This idea for a screw propeller was communicated from abroad to Charles Commerow, who took out a patent in 1828. The original drawings of this invention show this screw propeller as applied at the bow and stern of several vessels, and also as placed between two boats fastened together. The propeller represented by the model consists of one whole turn of a screw.

99. Varying pitch SCREW PROPELLER. Original design, full size, by the late Bennet Woodcroft, 1844. Iron.

Lent by Mrs. B. Woodcroft. 1876.

Note.—The object realised in this invention is that through suitable arrangements attached to the screw boss, the angle which the blades of the screw form with their shaft or axis can be altered from less to greater or from greater to less, in order to obtain the best pitch for driving a ship under varying circumstances.

100. DRAWINGS, framed and glazed. Early screw propellers applied to the propulsion of ships.

Lent by Mrs. Bennet Woodcroft. 1876.

Note.—Coloured drawing of H.M.S. "DWARF," fitted with Woodcroft's screw propeller, 1840–43; details of the screw. Pencil sketch, screw propellers designed by A. Nasmyth, 1819.

104. DRAWING, coloured, of a method proposed by Messrs. E. J. Reed, C.B., and H. Wimshurst, for raising and lowering the screw propeller of steam ships according to their draught of water. Proposed 1875–76.

Mr. H. Wimshurst. 1876.

105. MODEL. Undership screw propeller. Auxiliary propeller. The Rev. J. N. Kilner's proposal.
Presented. 1878

106. MODEL, illustrating Mr. J. J. Kunstädter's screw rudder for steering steamships. The steering screw is attached to and driven by the main screw shaft of the steamship by means of a universal joint, also the exhibitor's invention.
Mr. J. J. Kunstädter, C.E. 1879.

Note.—The steering screw when fitted as supplementary to the true propeller of the ship, is found to give the best results, if about $\frac{7}{10}$ths of the screw's diameter and of coarser pitch.

107. MODEL, in brass. Mr. J. J. Kunstädter's universal joint for the transmission of power.
Mr. J. J. Kunstädter, C.E. 1879.

108. SCREW PROPELLER. The Mallory propeller; model, in wood, on about $\frac{1}{4}$ scale.
The Mallory Propeller Co. 1879.

Note.—The Mallory propeller, the invention of Colonel Mallory of the United States Army of America, was introduced into England in 1878. Its features are that the screw is driven by vertical or upright gear working in a fish-shaped casing. The casing and its driving gear are capable of rotation on a vertical axis. The screw drives the vessel, whilst rotation round its vertical axis converts the propeller at same time into a rudder, and steers the vessel. As the propeller can be rotated a complete circle, the vessel is driven ahead, astern, sideways even, stopped, started, or turned about with great rapidity.

109. MODEL. Working model of King's shaft-coupling. 1874. For securing and temporarily working broken shafts of steamships.
Messrs. J. M. and T. D. M. King. 1879.

Note.—The model illustrates the principles of the construction and arrangement of this coupling for the temporary repair at sea of broken propeller shafts of steamships. The coupling is made in four parts, two of which are placed round each end of the broken portion of the shaft, and are firmly bolted together by nuts and bolts. They form two butts, which have their face recessed out sufficiently to admit the original butts of the shaft. The temporary coupling, when securely bolted together round the shaft breakage, is brought together and bolted by bolts and nuts through its own butts. The coupling is keyed up tight on the shaft by keys hollowed on their under side, and held fast in place by

binding or pinching screws, which avoids the necessity of cutting key-ways.

110. MODEL. Bevis's Feathering screw propeller. Messrs. Laird Brothers, Birkenhead. 1879.

Note.—Mr. R. R. Bevis, of the firm of Messrs. Laird Brothers, of Birkenhead, in 1868 patented an arrangement for altering the pitch or feathering the blades of a screw propeller in a fore and aft direction, which claims to be a great advantage for screw steamers, making them faster and more handy when under sail alone, and when under steam and sail allowing of adjusting the pitch to obtain the best result. A screw propeller of the ordinary kind, whether fixed or revolving, is a heavy drag against speed and handiness for sailing, and "lifting" it is a laborious operation, and requires a large hole or well through the ship's counter to admit of so doing.

The arrangement of this new screw propeller is free from many of the objections which have been made to feathering screws previously tried. The gear for feathering the blades is well protected, the levers and other gear that move the blades being enclosed within the boss of the screw propeller, and attached to a rod passing through the centre of the shaft, which is worked in the screw-shaft tunnel. The operation of altering the pitch, or of feathering the blades to any angle, is done in a few minutes, without in any way putting the engines into such a position that they may not be used in an emergency.

111. SCREW PROPELLER. Model in metal. ¼ full size. Three-blade screw propeller, used for driving swift torpedo steamboats and steam launches.

Lent by Messrs. J. and G. Rennie, Holland Street, Blackfriars, S.E. 1879.

Note.—The screw represented by the model is 5 ft. 4 ins. in diameter, and has a pitch of 6 ft.

112. MODELS of screw propeller arrangements. Five models of the after parts of screw steamships, to illustrate R. Griffiths' plans for the improved emplacement, driving power, and protection of the screw propeller. The late Mr. R. Griffiths. 1880–1.

Lent by Mr. W. J. Griffiths. 1882.

113. COLOURED DRAWING. Screw propellers. A series of 28 drawings in one glazed frame, showing the forms of screw propellers as patented by inventors between the years 1785–1849. The drawing compiled by E. J. Powell, 1850.

Transferred from the Patent Museum. 1886.

Note.—This drawing represents the screw propellers devised by the following inventors and engineers:—Joseph Bramah, 1785; William Lyttleton, 1794; Charles Cummerow, 1828; William Church, 1829; Bennet Woodcroft, 1832; Pettit Smith, 1836; John Ericsson, 1836; James Lowe, 1838; John Coope Hadden, 1839; George Rennie, 1839; Edward John Carpenter, 1840; George Blaxland, 1840; William Joest, 1841; Thomas Sunderland, 1843; Earl Dundonald, 1843; Robert Hodgson, 1844; George Beadon, 1845; Charles Henry Joseph Foret, 1845; John Samuel Templeton, 1846; John Buchanan, 1846; John Macintosh, 1847; Gardner Stow, 1848; Alexander Mitchell, 1848; Joshua Taylor Beale, 1848; John Hick, 1849; Ethen Campbell, 1849; Robert Griffiths, 1849; William Buckwell, 1849.

Besides the foregoing names connected with the invention of the screw as a ships' propeller, the under-mentioned are also notable:—Dr. Robert Hooke, 1681; Elijah Galloway, 1727–1731; John Fitch, 1796; Commander Samuel Brown, R.N., 1825; Steinman, 1839–40; John Seaward, 1849; Henry Maudslay, 1846–1858; John Fisher, 1853; Henry Walduck, 1854; Mrs. Lowe Vansittart, 1868; R. R. Bevis, 1868; Dr. Collis Browne, 1873; Charles Spruyt De Bay, 1876; J. and G. Rennie, 1878; Jacob Joachim Kunstädter, 1878; Colonel W. Mallory, 1878; Lieutenant R. H. Armit, R.N., 1878; Yarrow & Co., 1884–5; J. I. Thornycroft, 1885; Ross and Duncan, 1886.

114. MODEL. Stern of a vessel fitted with a four-bladed screw. J. Bramah. 1749–1814.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

Note.—In 1785 Joseph Bramah takes out a patent both for paddle wheels and screw propellers. He describes his screw as having inclined (oblique) wings or fans similar to the fly of a smoke jack. In working, the propeller was to be entirely submerged.

115. MODEL. Stern of a vessel fitted with screw propeller. W. Lyttleton's patent, 1794.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

Note.—William Lyttleton, a merchant of London, takes out in 1794 a patent for a screw propeller to be driven by a capstan turned by men.

116. MODEL. Stern of a vessel fitted with a two-bladed screw propeller. E. Shorter's patent, 1800.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

Note.—Edward Shorter, London, patents in 1800, a screw propeller, which appears to have been fitted to and tried with the ship "DONCASTER" in 1802. Shorter seems to have tried subsequently many forms for screw propellers. They were to be placed for service in the dead wood of ships or at their quarters, and were to be entirely submerged.

117. MODEL. Stern of a vessel fitted with screw propeller. C. Cummerow's patent, 1828.

Contributed. 1861.

Transferred from the Patent Museum. 1885.

Note.—Charles Cummerow, a merchant of London, patents in 1828, a screw propeller. Cummerow's invention appears to have been one of the earliest practical screw propellers.

118. THE SCREW PROPELLER of H.M.S. "RATTLER." B. Woodcroft's patent, 1832. This propeller (two blades) is formed with an increasing pitch. It is made of gunmetal, and weighs 26½ cwts., diameter 10 ft. 1 in., mean pitch 11 ft., length 1 ft. 6 ins.

Contributed by the Admiralty.

Transferred from the Patent Museum. 1885.

Note.—The "RATTLER," built and launched at Sheerness Dockyard, 1843, broken up 1856, was a vessel of 888 tons, and was fitted with Maudslay's double-cylinder engines of 200 nominal horse-power. She was the first screw propeller vessel-of-war in the Royal Navy, and this screw was used more or less till the vessel was broken up.

119. MODEL. Stern of a vessel fitted with two screw propellers. J. Ericsson's patent, 1836.

Contributed. 1861.

Transferred from the Patent Museum. 1885.

Note.—John Ericsson, a Swedish officer, but later an engineer established in London, in 1836 fitted out a steamboat propelled by a screw of his own design. The steamer "FRANCIS B. OGDEN," appears to have been fitted with two screws (twin screws) and to have realized a speed of 10 miles per hour.

120. MODEL. Stern of a vessel fitted with four separate screw blades. J. Lowe's patent, 1838.

Contributed. 1861.

Transferred from the Patent Museum. 1885.

Note.—J. Lowe's propellers appear to have at first taken the form of multiple blade screw propellers. They were from time to time altered and arranged in various forms, and tried with more or less successful results. The Lowe-Vansittart propeller of 1868 was a two-bladed screw devised

by Mrs. Vansittart, James Lowe's daughter, and tried by the Admiralty in H.M.S. "DRUID," in 1869.

121. MODEL. Conoidal screw propeller. Patented in 1839, by George Rennie.

Presented 1859.

Transferred from the Patent Museum. 1885.

Note.—George Rennie, engineer, Blackfriars, London, patents the conoidal screw propeller in 1839, together with improvements in paddle wheels and their floats. Rennie's screw propeller was to work entirely submerged, and was composed of "leaves" or "plyers" of curvilinear form attached round a shaft.

122. ORIGINAL VARYING-PITCH SCREW PROPELLOR. Gun-metal, full size. B. Woodcroft's patent, 1844.

Contributed by the Admiralty. 1857.

Transferred from Patent Museum. 1885.

Note.—The diameter of the screw is 5 ft. 8 ins. The angle which the two blades form with the shaft may be altered to such an extent, that the pitch will range from $4\frac{3}{4}$ ft. to $10\frac{3}{4}$ ft. It was made by Mr. Whitworth, of Manchester, and sent to Woolwich, September, 1846. It was never fitted to any vessel.

123. MODEL. Stern of a vessel fitted with two bladed screw propeller, showing a method of fixing the blades. John Seaward's patent, 1846.

Contributed. 1861.

Transferred from the Patent Museum. 1885.

124. MODEL. Stern of vessel fitted with a two-bladed screw propeller, to show method of unshipping. John Seaward's patent, 1846.

Contributed. 1861.

Transferred from Patent Museum. 1885

125. MODEL. Stern of vessel, fitted with a two-bladed screw propeller, to show method of unshipping. John Seaward's patent, 1849.

Contributed. 1861.

Transferred from Patent Museum. 1885.

Note.—This screw is also described as Seaward and Apel's Auxillary Propeller for a 90 gun ship of war.

126. MODEL. Stern post and screw well, illustrating plan for unshipping screw propellers. J. Maudslay's patent, 1846.

Contributed. 1861.

Transferred from Patent Museum. 1885.

127. MODEL. Stern of vessel, fitted with a two-bladed feathering screw propeller. J. Maudslay's patent, 1848, 1853.

Contributed. 1857.
Transferred from the Patent Museum. 1885.

128. MODEL. Two-bladed screw propeller. R. Griffiths' patent 1853 and 1859.

Transferred from the Patent Museum. 1885.

Note.—The Griffith's screw propeller first appeared as a patented invention about 1848 or 1849, and from that date until Mr. Robert Griffiths' death in 1883, many patents and devices for the amelioration of screw propellers were the outcome of his ingenuity. The Griffith's screw still maintains a prominent position for efficiency. Its principle feature is the large boss or hub to which the blades of the screw are fixed, and the tapering form of the blades.

129. MODEL. Four-bladed screw propeller. W. J. Griffiths' patent, 1880.

Contributed. 1881.
Transferred from the Patent Museum. 1885.

130. MODEL. Two-bladed screw propeller. John Fisher's patent, 1853.

Contributed. 1880.
Transferred from the Patent Museum. 1885.

Note.—John Fisher's patent consisted chiefly in cutting slits in the screw blade faces. The slits vary in size or area according to their position in the blade; they appear to have been devised for relieving the shocks experienced by the revolution of submerged screw propellers.

131. MODEL. Two-bladed screw propeller. H. Walduck's patent, 1854.

Presented. 1857.
Transferred from the Patent Museum. 1885.

Note.—Walduck's screw has serrated blades. The serrations are of varying area or size (length and depth), according to their position in the working side or face of the blades.

132. MODEL in metal. Two-bladed screw propeller. A. Mitchell's patent, 1854.

Transferred from the Patent Museum. 1885.

Note.—This model was contributed in 1861 by the Society of Arts.

133. Two MODELS. Two-bladed screw propellers. G. Peacock's patent, 1855.

Contributed. 1862.
Transferred from the Patent Museum. 1885.

134. Screw propeller. MODEL in metal. Feathering screw propeller. Wm. Hewitt's patent, 1855.
Contributed. 1863.
Transferred from the Patent Museum. 1886.

135. MODEL. Two-bladed screw propeller, fitted H.M.'s floating battery "THUNDERBOLT," about 1856.
Transferred from the Patent Museum. 1885.

136. MODEL. Stern of a vessel fitted with a two-bladed screw propeller. W. H. Crispin's patent, 1860.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

137. Two MODELS in metal. Two-bladed screw propellers. W. H. Crispin's patent, 1860.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

138. WHOLE-BLOCK MODEL. A double ended vessel, fitted at each end with a two bladed screw propeller. The model represents a design for a steam ram. Invented by Wm. Batten.
Contributed. 1862.
Transferred from the Patent Museum. 1885.

139. MODEL. Stern of a vessel and two-bladed screw, showing an invention for protecting screw propellers.
Transferred from the Patent Museum. 1885.

Note.—The inventor of this proposal for the protection of screw propellers is not known. The model was contributed in 1868. Protection to screw propellers have been planned frequently. J. I. Thornycroft, and the late R. Griffiths, amongst others, being workers in the matter.

140. MODEL. Stern of a vessel fitted with two-bladed screw propeller.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

141. MODEL. Vessel fitted with two stern or twin-screw propellers. Invented by Captain A. N. Skinner, R.N., Belfast, about 1860.
Contributed. 1861.
Transferred from the Patent Museum. 1885.

142. MODEL. Stern of vessel fitted with a two-bladed screw propeller.
Transferred from the Patent Museum. 1885.

143. ORIGINAL SCREW PROPELLER SHAFT BEARING. John Penn's patent, 1857. Recovered from the wreck of the S.S. "Royal Charter," after being submerged for nearly two years.

Presented 1861.

Transferred from the Patent Museum. 1885.

Note.—This propeller shaft bearing, or screw shaft thrust block, is lined with strips of "lignum vitae" or wood, in accordance with John Penn's patent, 1854–7. It had been used over a distance exceeding 188,000 miles, without exhibiting any material signs of wear. The S.S. "ROYAL CHARTER," iron-built, 1858–9, tons, 2,719, 200 nominal horse-power, was wrecked in Moulfra Bay, Anglesea, on 26th October 1859.

144. TWO MODELS. Theoretical models, constructed to show the action of the screw propeller in the water.

Contributed 1861.

Transferred from the Patent Museum. 1885.

Note.—These two models, illustrating the action of screw propellers of different pitch of screw thread, as they drive through the water at the stern of a ship, were contributed in 1861 by Jackson and Watkins, Engineers.

145. SCREW PROPELLERS. Four examples in brass of cycloidal screw propellers, invented by Lieut. Robert H. Armit, R.N., 1878.

Contributed.

Transferred from the Patent Museum. 1886.

146. MODEL. Duncan's patent screw propeller, with frame and rudder as fitted to the Egyptian Government's Coastguard yacht "SAREEA."

Presented by Messrs. Ross and Duncan, Whitefield Works, Govan, Glasgow. 1887.

Note.—This three-bladed screw propeller was patented by Mr. R. Duncan, in 1886. The blades are curved peculiarly, and would appear to be improved thereby for grip of water.

For photographs of the "Sareea" and her engines, see pages 81, 203.

147. MODEL. J. Lowe's multiple blade screw propeller.

Lent by Mrs. Bennet Woodcroft. 1876.

Note.—In 1838 James Lowe patented his designs for screw propellers, on the improvement of which he continued working for some 20 years. The six-bladed screw represented by the model is said to have been fitted to the celebrated "GREAT BRITAIN" screw steamship, 1843. It has also been attributed to Bramah.

Miscellaneous Propellers.

150. Model of a propeller for small vessels and boats. Mr. S. F. Pichler. London. 1876.

Note.—The model represents a propeller designed about 1860 to have a motion similar to that of an oar when used in sculling at the stern of a boat.

151. Ruthven's hydraulic or turbine propeller. Half Model of H.M.S. "Waterwitch," built of iron by the Thames Iron Works Company in 1866. Tons burden 778, nominal horse-power 160.

Received. 1869.

Note.—H.M.S. "Waterwitch" is propelled on the hydraulic or turbine principle, proposed and developed by Mr. D. Ruthven in 1843, 1849, 1866. By means of the turbine driving water supplied to it through ships' bottom out through horizontal pipes running fore and aft on lines of ship's floatation, the "Waterwitch" attained a speed of about 9¼ knots per hour. The three-cylinder horizontal steam engines, driving the turbine wheel 14 ft. in diameter, were constructed by Messrs. Dudgeon, of London, 1866. Dr. John Allen proposed in 1730 the water jet propeller, and again Rumsey, in 1784, in America.

Note on various Propellers.

The "Propeller," an iron built vessel, ran on the Thames about 1845, having two dash boards worked by a steam engine, in lieu of paddle-wheels. From the walking action of these propellers she was called the Daddy-long-legs. Another small boat appeared on the Thames driven by a huge dash board working at the stern in lieu of a stern paddle-wheel.

In 1876, at the Scientific Exhibition of the year, held at South Kensington, a working model of a boat driven by an undulating or sinuous propeller, the invention of A. H. Garrod, was exhibited.

Again, in 1882, at the Royal Agricultural Hall, Islington, there was exhibited by Messrs. Duncan Brothers, Engineers, a steam launch driven by a propeller of the dashboard type, known as the duck's foot type of propeller, the proposal of Mr. Walton, and called his patent feathering propeller.

At the Inventions Exhibition, 1885, at South Kensington, Captain T. B. Heathorn, late Royal Artillery, exhibited his mechanical propeller, which, when driven, had a motion similar to that of a single oar sculled at a boat's stern. The propeller served also as a rudder, and was either single or double bladed; the latter when the blades were extended athwart ships acted as a brake. These propellers have been used by the inventor to drive a pleasure boat on the Thames, fitted out by him.

CLASS V.

Appliances used in Ships.

Note on Steering Apparatus.

Steering a ship means the use of power provided for guiding and changing her direction (course) through the water. To some extent the sails of a ship will supply steering power, and when she is driven by steam power, twin-screw propellers or disconnective paddle-wheels, her course may be directed by the proper use of them.

The rudder is, however, the ancient and most efficient mode of controlling a ship's course. It is hung to the stern of a vessel, its immersed part being a flat plate or surface of wood or of iron in a vertical position, and capable of turning into different angular positions about a vertical axis.

The ordinary rudder when hung at the stern of a ship to the rudder-post by means technically termed "pintles," and "braces," has its axis at its forward edge.

The rudder known as the "balanced rudder," has its turning axis usually at one-third the breadth of the rudder from its forward edge, and the rudder turns on a pivot on its under end. supported by the purposely projected after-end of the ship's keel. Earl Stanhope is said to have invented the balanced rudder in 1790. In 1819 and in 1863, exhaustive experiments with it were conducted.

Rudders are also fitted at the fore-end as well as the after-end of vessels driven by steam power and intended to run either end first.

In order that rudders may be efficient in turning a ship, it is necessary that the latter shall have motion, and that the speed of the ship shall be sufficient to cause the water to act upon the face of the rudder with enough pressure to turn the vessel. It is also necessary that the motion of the water striking the rudder should consist of a steady flow astern relatively to the motion of the ship. Hence it is requisite that the lines of the after body should be fair and fine, so as not to drag a volume of water after the vessel, or set the water in motion in any other way than directly astern. In proportion as the flow of the stream meeting the rudder deviates from a fore and aft direction, the action of the rudder will fail in efficiency.

The rudder must be moved on its axis by some mechanical power (usually lever power), and this power or lever is termed the "tiller." The tiller is again moved through its prescribed motion from the central line or keel line towards one side or the other of the ship by man power, or by

mechanical powers such as blocks and tackle, steering wheels and their gear, hydraulic power apparatus, and steam power apparatus. The two last termed respectively "hydraulic steering gear," and "steam steering gear," are employed to drive the tiller and the rudder when the latter is of such large surface and the ship so heavy that man-power would be generally too slow and exhausting to effect with sufficient rapidity and certainty the steering of heavy vessels under the varying circumstances of navigation.

The steering of a ship or steamer from the fore end instead of at the after end was proposed and carried out by Wm. Symington in 1802.

STEERING APPARATUS. RUDDERS, PERMANENT AND TEMPORARY. STEERING GEAR OF ALL KINDS. MANUAL AND STEAM GEAR.

1. MODEL of the stern of a screw frigate showing Admiral Martin's plan (1858) for steering apparatus, arranged to work the rudder-head clear of the screw well. 1864.

Note.—The tiller, tiller-ropes, &c. all work on the starboard quarter.

2. MODEL of a proposed steering apparatus, 1861. 1864.

3. MODEL of a double rudder fitted to stern of a screw steamer. Proposed by Lieut. the Hon. J. Fitzmaurice, R.N.
Lieut. the Hon. J. Fitzmaurice, R.N. 1865.

4. MODEL of a balance rudder.
Proposed and presented by Mr. J. S. Tucker. 1865.

5. MODEL of the stern of a ship fitted with J. Scott Tucker's proposed balance rudder, which can only be unshipped when at right angles with the keel.
Presented by Mr. J. S. Tucker. 1865.

6. MODEL of a flat-bottomed schooner, with an outside tiller. About 1820.
Presented by Mr. J. S. Tucker. 1865.

7. THREE MODELS showing various systems of "Lumley's" patent rudder. 1862.
Invented by H. Lumley, Assoc. I.N.A.
Lent. 1865.

8. ENGRAVINGS of "Lumley's" rudder, showing its modifications.

Lent by Mr. H. Lumley, Assoc. I.N.A. 1865.

9. MODEL of "Blake's" plan for adding power to the rudders of gunboats, and vessels of light draught. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards. 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

10. MODEL of "Blake's" plan for constructing a temporary rudder. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

11. MODEL of the rudder of a ship of war, wood construction, showing arrangement and scarfing of the timbers, disposition of the braces, rudder head, and other portions. Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

12. MODEL of R. Napier and Sons' patent screw steering gear, fitted to the French Mail Atlantic steam ship "CITY OF PARIS," screw, and now usually fitted by them to large ocean steam ships.

Presented by R. Napier and Sons, Glasgow. 1867.

13. WORKING MODEL of a ship's steering wheel known as the "Niagara" wheel, because fitted on board the United States corvette, "NIAGARA." Designed 1857.

Mr. Andrew Murray, Chief Engineer, Portsmouth Dockyard. 1867.

Note.—The rudder head is suspended on friction rollers, and the screw gear to move the rudder is of special mechanical arrangement.

14. MODEL balance rudder and arrangement of stern for twin-screw steamships (iron built). Proposed by the late C. W. Merrifield, F.R.S.

The late Mr. C. W. Merrifield, F.R.S. 1869.

15. MODEL, illustrating Admiral E. A. Inglefield's invention. The "Hydrostatic" steering apparatus, for heavy ships. The model shows the method adopted in fitting the apparatus to H.M.S. "ACHILLES," 6,000 tons, 1,250 horse-power nominal.

Admiral E. A. Ingefield, R.N., C.B., F.R.S. 1871.

Note.—H.M.S. "ACHILLES," iron, 20 guns, 1,250 horse-power, armour plated, screw ship. Length 380 ft., breadth 58 ft. 3½ ins., depth 21 ft. 1½ ins., tonnage 6,121. Laid down at Chatham Yard in August 1861 in a dock, undocked in December 1863. Designed by the Controller's Department, Admiralty, on lines very similar to H.M. ships "WARRIOR" and "BLACK PRINCE," built in 1860.

The armament is as follows:—

	No.		Prs.
Main deck	8	-	100-pr. 6½-ton guns.
	8	-	6½-ton rifled guns.
Upper deck	4	-	6½-ton "
	20		

Her complement of men, 705.

16. MODEL of bow of vessel, showing bow rudder with guard on. Patent taken out by the late Mr. John Laird in 1843.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—Very generally adopted for all double-ended river steamers, and fitted in several paddle-wheel gun vessels.

17. MODELS. Three working models illustrating exhibitor's patent steering gear for double rudders.

Lent by Captain T. B. Heathorn, Wilton Place, S.W 1879.

Note.—The models represent the sterns of ships, and show three methods of moving the duplex rudders independently or simultaneously as well as their various positions.

The rudders apply to steering the vessel whilst under way, and to checking her very suddenly when required to do so.

18. Self-holding steering gear. HAND POWER WORKING ILLUSTRATION, full size. Archer's patent, 1882.

Lent by the Dunstan Engine Works Company, Gateshead-on-Tyne. 1883.

Note.—In consequence of the self holding power in this steering apparatus it has firmly established itself as a manual steering gear. It can also be driven by steam power. The illustration is suitable for small vessels only.

19. Steel rudder. MODEL. Crucible cast steel stern frame and solid rudder. Manufactured 1881 by the exhibitors to the design of Mr. J. F. Hall.

Lent by Messrs. Wm. Jessop and Sons, Limited, Brightside Works, Sheffield. 1884.

Note.—Cast steel stern frames and rudders for steel or iron built vessels, Messrs. Jessop and others now manufacture freely. The material at first was considered doubtful, but the quality of it in consequence of the advances in manufacture have greatly overcome prejudice.

20. RUDDER and STERNPOST, showing improved method of attaching rudders to boats and vessels.
Lent by Mr. Henry Emanuel, Surbiton, S.W. 1885.

Note.—The patent consists of using a continuous spindle between the rudder straps and a slotted barrel on the boat, instead of the ordinary pintles and gudgeons, so that the rudder may be shipped afloat under any conditions. It also prevents the rudder unshipping in a sea-way, or if the boat take the ground aft.

21. TELESCOPIC TILLER for small sailing boats.
Lent by Mr. Hy. Emanuel, Surbiton, S.W.

For model of bilge-valve and shaft disconnector, see pages 196, 260.

22. Screw steering gear. MANUAL. McWilliams' steering gear.
Messrs. Hastie, Kincaid, & Co., Greenock.
Contributed. 1870.
Transferred from the Patent Museum. 1885.

23. WHOLE MODEL. Light draught screw steamer for shallow river navigation. Designed by Alexander Chaplin, 1856.
Contributed. 1862.
Transferred from the Patent Museum. 1885.

Note.—This model represents a shallow draught steamer with all cabin and promenade accommodation erected on the upper deck, a plan still in vogue for this class of vessel. She is steered from amidships from a wheel on top of the accommodation which forms the promenade deck.

24. SMALL SIZE STEAM STEERING GEAR for yachts and small craft. Photographs of steering gear; (framed).
Lent by Messrs. Amos and Smith, Hull.
1887.

Note.—Steam steering gear is now applied to every class of vessel propelled by steam power. The methods of application are too numerous to enter into in this place, but this working representation in the collection is a good example of steam steering gear. Like most of such appliances, it can be used with or without steam power. Hydraulic power has also been applied successfully to heavy steering apparatus.

25. STEAM STEERING GEAR. Noiseless gear worked by steam alone.

Lent by the Harrison Steering Engine Company, Salford, Manchester. 1888.

Note.—Harrison's steering gear was introduced about 1882. The engines are under complete control and follow the motions of the hand or steering wheel instantly. The gear works without shock or noise of any kind. It is also constructed to work by hand-power only, steam-power only, or by both.

CAPSTANS AND WINDLASSES.

Note.—These appliances used in ships for manipulating anchors, yards and sails, cargo, haulage, and the general labour aboard ship, are not represented at present.

The objects themselves, full size, would be too cumbersome for the space available for their exhibition. Models of patent windlasses, manual or steam power ; capstans; manual or steam power hoists; and similar labour saving modern appliances aboard ship, could be readily accommodated and added to the ship model and marine engineering collection, either as loans on exhibition, or permanently as contributions.

26. "FISHER BOY." Double geared winch for hauling nets, raising masts, sails, and general work of fishing vessels.

Messrs. Harper and Co., Aberbeen. 1883.

Note.—The "Fisher Boy" winch is chiefly adopted on the North sea fishing craft of Scotland.

27. FISHING BOAT. Transverse section of a steam trawling vessel, showing the arrangement of a steam engine and gear for driving a capstan for hauling in the trawl net, and other work.

Mr. William Knox, Douglas, Isle of Man. 1883.

Note.—The capstan is driven by a high pressure engine having two cylinders, each 3 ins. in diameter, and arranged at right angles to each other (one being horizontal, and the other vertical). The engine will start from any position of rest. A vertical boiler, 4 ft. 6 ins. high, and 2 ft. 6 ins. diameter, supplies steam at 60 lbs. per sq. in. pressure.

The model hull also shows a cooking hearth in position, and a portion of the bunks or berths of the crew.

28. MODEL of ship's deck fitted with a windlass and apparatus for relieving the strain on ships' cables and decks. W. H. Muntz's patent, 1860.

Contributed. 1862.

Transferred from the Patent Museum. 1885.

29. MODEL of portion of ship's deck, showing two methods of employing compressors for chain cables. W. Batten's patent, 1831.
Transferred from the Patent Museum. 1885.

ANCHORS AND CABLES.

31. THREE COMPRESSORS for chain cables. *a.* Original; *b.* As proposed by the Surveyor of the Navy, Sir William Symonds; *c.* As proposed by the Plymouth Yard officers. 1835. 1864.

32. DROGUE. A canvas floating anchor about 2 ft. square, used by fishing and other boats, to keep under weigh and head to sea.
Presented by the late C. W. Merrifield, F.R.S. 1869.

33. MODEL of "Blake's" slip hook for mooring chains. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

34. MODEL showing "Blake's" stoppers for letting go anchors. Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.
Presented by the Rev. J. Hardie, Falmouth. 1866.

35. MODEL, snatch block, standard or pendant, for hauling in deep-sea lead lines. Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.
Presented by Rev. J. Hardie, Falmouth. 1866.

36. MODEL, wood, illustrating part of a proposed toggle. Designed by Mr. R. Blake, Master Shipwright, H.M.'s Dockyards, 1806–1855.
Presented by Rev. J. Hardie, Falmouth. 1866.

37. MODEL of the bows of an armour-plated ship of war, illustrating Martin's patent self-canting anchors; and their housing in-board, &c. Also models in wood of Martin's chain cable links, with patent zig-zag welded joints.
Mr. C. Martin. 1874.

38. MODEL in silver. "Stockless" Anchor. Small craft anchor.
Lent by Mr. Wasteneys Smith, Newcastle. 1876.

39. MODEL in brass. "Stockless" Anchor.
Lent by Mr. Wasteneys Smith, Newcastle. 1876.

Note.—This anchor is said to possess—

Great holding power, with less weight, besides being diminished in the weight of the stock.

Extraordinary strength, proved at Lloyd's test.

It is always canted, no matter how it falls, and requires no stock to keep it canted.

Being always canted when on the ground, and by the assistance of the horns or toggles, it takes hold as soon as any strain is put upon the cable.

Spare, wider, and different shaped arms for various grounds may be carried on board.

It will not foul or get fouled, and when holding there is nothing above ground, nor is there any stock to cause accidents.

It trips with great ease, because there is no stock to lift, and the crown end has so large a surface that good purchase is obtained for weighing.

It is easily fished, and can be stowed in-board on deck, thus clear of the bow, and avoiding risk of damage in case of collision of any description.

A ship may be speedily brought up by it, and ride with very short cable; the steadying power being at the crown end, it is of no object if the shank is raised off the ground, which stocked anchors will not allow.

Should the anchor be difficult or dangerous to weigh, from having got fast in rock or wreckage, a runner with messenger attached may be slipped down the cable to the crown end, and by this means the anchor can be drawn out freely, as there are no barbs or palms to retard it.

Three photographs representing Mr. Wasteneys Smith's "stockless" anchors, aground and slung, are also in the Museum.

Presented. 1876.

40. MODEL of an anchor invented by Sir Edward Belcher when a midshipman, 1815.
Admiral the late Sir Edward Belcher, K.C.B.
1876.

41. MODEL of a method of mending an anchor when the shank has been broken, 1830. The method is by means of three pieces of pig-iron.
Admiral the late Sir Edward Belcher, K.C.B.
1876.

42. MODELS (two) of portable anchors. Designed by Captain A. Thomas Swinburne, late R.N., Salen, Fort William, N.B.
Lent. 1877.

43. GRAB LINK. For holding chain cables, and other uses. The Rev. J. N. Kilner's patent.
Presented. 1878.

44. MODEL. Hollow shanked anchor. Lieut. Wm. Rodgers', R.N., patents, 1828, 1829.
Presented. 1857.
Transferred from the Patent Museum. 1885.

45. MODEL. Small palmed anchor. Lieut. Rodgers', R.N., patent, 1833.
Presented. 1857.
Transferred from the Patent Museum. 1885.

Note.—This model has one palm of the usual size by way of contrast with the small palms for anchors proposed by Lieut. Rodgers.

46. MODEL. Double, concave, small palm anchor. Lieut. Wm. Rodgers', R.N., patent, 1846 and 1853.
Presented. 1857.
Transferred from the Patent Museum. 1885.

47. TWO MODELS. Portions of anchors showing the difference between the Admiralty anchor of 1840, and Rodgers' anchor of about 1846.
Contributed by Lieut. W. Rodgers, R.N., in 1857.
Transferred from Patent Museum. 1885.

Note.—In this model two anchors are placed side by side for comparison of the Admiralty pattern anchor of 1840 with Lieut. Rodgers' small palm anchor of 1846.

48. MODEL. Scale of 1 in. to 1 ft. Bower anchor. J. Trotman's patent, 1852.
Presented. 1862.
Transferred from the Patent Museum. 1885.

Note.—The steamship "GREAT EASTERN" was furnished originally, 1857, with Trotman anchors. Trotman anchors are still used in the Imperial and merchant marine.

49. MODEL of an anchor. R. Roberts' patent, 1852.
Contributed.
Transferred from the Patent Museum. 1885.

50. MODEL of an anchor. C. Martin's patent, 1859.
Contributed. 1860.
Transferred from the Patent Museum. 1885.

Note.—This model represents the late Claude Martin's anchor, which to the present time has remained appreciated both in the Imperial and merchant marine services.

See also No. 37.

51. MODEL of an anchor. S. Hunter's patent, 1862.
Contributed. 1862.
Transferred from the Patent Museum. 1885.

52. TWO MODELS of anchors. Invented by J. Aylen, R.N., 1885.
Presented. 1862.
Transferred from the Patent Museum. 1885.

53. MODEL of the upper portion of an anchor. Wm. Piper's Patent, 1822.
Contributed. 1863.
Transferred from the Patent Museum. 1885.

54. MODEL, in rough iron, of an anchor. The inventor not known.
Contributed. 1885.
Transferred from the Patent Museum. 1885.

55. MODEL of an anchor. J. Coryton's invention.
Contributed. 1874.
Transferred from the Patent Museum. 1885.

56. MODEL of an anchor. Captain Peacock's invention.
Contributed. 1862.
Transferred from the Patent Museum. 1885.

57. MODEL of an anchor. The inventor not known.
Contributed. 1859.
Transferred from the Patent Museum. 1885.

58. PHOTOGRAPH. Bow of Brazilian ironclad, "RIACHUELO," showing Baxter's patent anchor, housing, seating, and hawse-holes.
Lent by Messrs. S. Baxter & Co., 18 and 19, Great St. Helen's, E.C. 1885.

Note.—The "RIACHUELO" was built in 1884 on the Thames, by Samuda Brothers, Poplar. The anchors and their stowing arrangements have since been applied to many ships of Imperial and commercial service.

Chain Cables.

Note.—Illustrations of chain cables used aboard ship are not represented at present in any form in the collection appertaining to ships.

Ships' Pumps, Tanks, &c.

Note on Pumps.

The pump, perhaps one of the most useful of inventions, may be considered under two classes.

The common or lift pump universally employed to draw water from wells sunk in the earth, and the force pump, used not only to draw water from any given source, but also at the same time to raise or force it upwards to any height which may be required, in order that the water thus elevated should again fall by gravity and supply the necessities of cities and dwellings.

The common lift pump, as well as the force pump, are usually worked by hand-power, but both of them, when constructed of very large size, are driven by steam-power for innumerable purposes.

Pumps are said to have been invented with other hydraulic machines by Ctesibius of Alexandria, about 224 B.C. The invention of pumps has also been ascribed to Danaus at Lindus about 1485 B.C. Pumps were in general use in England in 1425 A.D. In front of the old Royal Exchange in the city of London there stood an old pump bearing an inscription to the effect, that the well underneath was sunk in 1282 A.D.

The air pump was invented in 1654 by Otto Guericke, German Philosopher 1602–1686, and improved upon 1657, by Robert Boyle, 1627–1691.

Ships' Pumps.

60. Ship's Pumps. Drawing of Stone & Co.'s piston and plunger standard pump for ships' use. J. Stone & Co., Deptford, S.E.

Presented. 1879.

Note.—A sectional drawing with full description of the principles and construction of these pumps, which are said to be practically unchokeable, and in any case, from their arrangement, any mishap can be readily seen to.

61. Self-acting Steam Ram Pump. The Pulsometer. Hall's patent, U.S.A.

Lent by the Pulsometer Engineering Company, 61 and 62, Queen Victoria Street, E.C. 1876.

Note.—Self-acting steam pump, a novel application of the general principle involved in Savery's engine, A.D. 1702. The result is produced by the pressure of the steam from the boiler upon the surface of the water in each chamber of the pump alternately, without the intervention of any steam piston or plunger, and the water is lifted into the chambers by a vacuum produced without injection or surface condensation. The action of the steam ball, which governs the pulsations, is purely automatic; the moving parts, including four valves, are five in number only.

Ventilation of Ships.

Note.—Models or illustrations of recent inventions and appliances for the perfect ventilation of sailing ships and steamships, their 'tween decks, passenger accommodation, and berthing, sanitary appliances, engine and boiler rooms, and the like, are very inadequately represented. There are many successful automatic or self-acting arrangements for thoroughly ventilating a ship in all her compartments and departments now adopted and applied to the purpose, such as those of Boyle and Son, London; D. C. Green, London; Oswald and Huff, Sunderland; Utley and Fawcett, Liverpool; Buchan, Glasgow, &c.

Models of Fitments.

Cabins and their fittings. Ports, Skylights, Hatchways, Ladders, &c. Fire-hearths and Stoves. Engines.

63. Model of "Blake's" method for ventilating troopships.

Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

64. Model of "Blake's" plan for barring in the ports, and showing method of ventilation.

Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

65. "Blake's" improved stopper bolt.

Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by the Rev. J. Hardie, Falmouth. 1866.

66. SECTIONAL MODEL of a ship's side, showing proposed arrangement 'tween decks for the transport of troops. The model represents accommodation for about 20 men.

Designed by Mr. R. Blake, Master Shipwright in H.M.'s Dockyards, 1806–1855.

Presented by Rev. J. Hardie, Falmouth. 1866.

67. MODEL. Original design for horse stalls, as fitted at Malta, to the ships that conveyed the troops to the Crimea, 1854.

Mr. W. Ladd, Deptford Dockyard. 1864.

68. MODEL on a scale of 3 ins. to 1 ft. of an ice house and cooling apparatus, fitted to the steamship "CATHAY" and other steamships of the Peninsular and Oriental Company. The model made by W. Denny & Brothers, Dumbarton.

Lent by the Peninsular and Oriental Steam Navigation Company, 122 Leadenhall Street, E.C. 1875.

70. DRAWING (lithograph), illustrating Price's Self-trimming Hatchways for Steam Colliers.

Mr. W. Denton, Sunderland. 1876.

Note.—The drawing represents a longitudinal through section of the screw steam collier, "J. B. EMINSON," built of iron at Sunderland. Scale $\frac{1}{8}$ in. to 1 ft. A midship section of the same collier loaded. Scale $\frac{1}{4}$ in. to 1 ft. Details of hatchways (side and end) for colliers ranging from 26 to 32 ft. beam.

71. BILGE emptying valve for small boats.

Lent by Mr. H. Emanuel, Surbiton, S.W. 1885.

For other models lent by Mr. Emanuel, see pages 196, 252.

73. TWO MODELS of improved plugs for boats. E. Vaughan's invention, 1860.

Contributed. 1860.

Transferred from the Patent Museum. 1885.

FIRE-ENGINES FOR SHIPS.

NOTE ON STEAM FIRE-ENGINES.

Fire-engines worked by steam power were introduced into England by Mr. John Braithwaite in 1829, and followed up in 1830 by an engine of six horse-power which worked successfully for five hours at a fire in London. In 1862 steam fire engines were permanently established in Great Britain.

The London Metropolitan Fire Brigade possessed (1886) 45 steam fire-engines on its establishment, some six or eight powerful steam-power floating engines on the river, which are essentially steamboats and fire-engines combined, propelled by paddle-wheels or screws, and attaining a high rate of speed.

Steam or manual power fire-engines are indispensible fittings aboard large vessels going long sea voyages.

Note on Manual Fire-engines.

The earliest manual fire-engine constructed in England appears to have been made by Richard Newsham, pearl-button maker, of London, who was granted a patent for his fire-engine in 1721–1725. These engines had two pumps and an air vessel combined together, so as to ensure a continuous and uniform discharge of water with considerable force. The invention of Newsham is still the leading feature in all fire-engines, whether driven by manual or steam power. In 1876, at the Scientific Apparatus Exhibition, a Newsham fire-engine was exhibited. It is mounted on four wooden wheels, 1 ft. 7 ins. in diameter. The body forms the reservoir for water to supply the pumps which drive the water into the air vessel and out of which the water is forced by the pressure of the compressed air within it, into the discharging hose or pipe. The pumps are worked by long levers of wood for hand-power, and by treadles for foot-power. The brass ejection pipe of the engine is $1\frac{3}{4}$ ins. in diameter, and it is screw-tapped in the usual manner to receive the hose pipe and nozzle.

In 1886 the Fire Brigade of the Metropolis possessed 114 manual power engines, 28 miles of water hose, besides land and floating steam fire-engines, with a full complement of their necessary adjuncts and appurtenances. Fire-engines, buckets, and hose, are supplied to, and form part of the equipment of every high-class sailing or steam vessel.

CLASS VI.

Appliances used in building and repairing Ships.

Docks and Harbours.

Floating Docks.

1. Sectional Model, showing 10th of the length of the iron floating docks at the Royal Spanish Arsenal, Carthagena and Ferrol, Spain. Built 1856–57.

Messrs. J. and G. Rennie, Blackfriars. 1876.

Note.—The model (in wood) represents the interior and exterior of these floating docks built by Messrs. Rennie for the Spanish Government, and within the model a $\frac{1}{10}$th portion of an iron armour plated ship of war of a total weight of 6,500 tons.

The dock measures 350 ft. total length, 105 ft. extreme breadth, 37 ft. 6 ins inside depth.

Displacement of base 13,000 tons. Total weight of dock complete 6,500.

This model, on a scale of 1 in. to 1 ft., shows the arrangements on the top sides, in the bottom, and other detail.

2. Whole Model of an iron floating dock. Built by Messrs. Randolph, Elder, & Co., Glasgow; for Port Saigon, Cochin China. For the French Government.

Messrs. John Elder & Co., Govan, Glasgow. 1876.

Note.—The dimensions of this iron floating dock are:—

Length extreme	-	300 ft.
Breadth ,,	-	94 ft.
Depth ,,	-	42 ft.

The dock will lift a ship of 4,800 tons weight, drawing 27 ft. of water. The weight of the dock is 2,800 tons.

3. Photographs of Campbell's floating dry dock, constructed of iron, for Her Majesty's Dockyard, Bermuda, 1868. Length extreme 381 ft., length inside 330 ft. Width extreme 123 ft. 1 in., width inside 83 ft. 1 in. Height extreme 74 ft. 5 ins., height inside 54 ft. 5 in.

Messrs. Campbell, Johnstone, & Co., Founders Court, Lothbury, E.C. 1876.

Note.—This iron floating dock for Bermuda was built by Messrs. Campbell, Johnstone, & Co., at Silvertown, North

Woolwich, and launched broadside on in September 1868. There are three photographs of this floating dock. One represents the dock before launching; a second represents the dock heeled over at Bermuda for cleaning. The third represents this dock carrying H.M.'s armour plated ship "ROYAL ALFRED."

The Bermuda floating dock will sustain ships of war of H.M.S. "FURY" class, iron armour plated ship of 10,000 tons burden.

4. PHOTOGRAPH of the floating iron dock at Bermuda; carrying H.M.'s armour-plated ship "ROYAL ALFRED," 4,068 tons, 800 horse-power, nominal.

Messrs. Campbell, Johnstone, & Co., Founders Court, Lothbury, E.C. 1876.

Note.—The extreme length of this dock is 381 ft. Length between caissons 330 ft. The extreme width 123 ft. 9 ins. Inside width 83 ft. 1 in. Extreme height 74 ft. 5 ins. Inside height 54 ft. 5 ins. The dock was finished and towed out to Bermuda in 1869.

5. MODELS. Working models illustrating the principles and construction of iron floating docks. (The Bermuda floating dock, 1868.)

Presented by Mr. A. J. Campbell, Lee Park, S.E. 1880.

Note.—The Bermuda floating dock, constructed of iron in 1868 by Messrs. Campbell, Johnstone, & Co., will carry an armour-plated ship of war of 10,000 tons burden. Its extreme length is 381 ft., extreme width 123 ft. 1 in., and extreme height 74 ft. 5 ins.

6. MODELS. Working models of carrying trays, for docking vessels. Keyham Dockyard.

Presented by Mr. A. J. Campbell, Lee Park, S.E. 1880.

7. WHOLE MODELS. Ships of war and others; for use in illustrating the supporting capacity of iron floating docks. (The Bermuda floating dock.)

Presented by Mr. A. J. Campbell, Lee Park, S.E. 1880.

Note.—The models represent the following ships:—H.M.S. "BLANCHE," 1867. Four guns, 350 horse-power. Length 212 ft., breadth 36 ft., draught 16 ft. 6 ins. aft., tons 1,268. H.M.S. "MINOTAUR," 1863. 50 guns, 1,350 horse power. Length 400 ft., breadth 59 ft. 4¾ ins., draught 24 ft. 1 in. aft., tons 6,621. H.M.S. "CROCODILE," 1866. Troopship, 700 horse-power. Length 360 ft., breadth 49 ft.,

draught 21 ft. aft., tons 4,206. Ironclad ship-of-war; model representing a vessel of 7,580 tons displacement, Half block model; steamer designed by Messrs. Campbell, Johnstone, & Co.

8. MODELS. Half-block models in wood; five in number. Showing detail and form of iron caissons for closing the entrances of permanent or floating docks. Messrs. Campbell, Johnstone, & Co., Engineers.

Presented by Mr. A. J. Campbell, Lee Park, S.E. 1880.

9. MODEL. Whole model in wood. The entrance and iron caisson of a permanent dock. Detail model. Messrs. Campbell, Johnstone, & Co., Engineers.

Presented by Mr. A. J. Campbell, Lee Park, S.E. 1880.

10. MODEL representing formation and construction of a proposed deep-water harbour in Filey Bay, coast of Yorkshire. Designed about 1870 by Sir John Coode, C.E.

The Home Office. 1877.

Note.—The anchorage enclosed by the breakwater as shown on this model would be completely sheltered in all winds, and its total area at low water ordinary spring tides would equal 750 acres.

380 acres area would have a depth of 5 fathoms and upwards, 200 acres would have a depth of 6 fathoms, and 60 acres would have a depth of 7 fathoms of low water ordinary spring tides.

An additional area of nearly 1,200 acres would also be sheltered from northerly and easterly winds.

11. MODEL showing the operations and construction of one of the docks by convict labour, at the new extension works, Chatham Dockyard. 1870. Scale of model:—For the area 20 ft. to 1 in.; for the width of entrances to docks 10 ft. to 1 in.; the basin, walls, men, horses, &c, 5 ft. to 1 in. The models were made by convicts at Chatham Prison.

The Home Office. 1877.

Note.—The addition to the dockyard at Chatham (of which this model shows a small portion as it actually appeared under construction by convict labour) covers a space of 430 acres, which is four times the extent of the old dockyard.

It occupies the site of St. Mary's Island, the original condition of which is shown by another model. The channel which separated the island from the mainland furnished the

position of the basins. The bottom of the basin is 12 ft. below the old river bed, and 32 ft. below St. Mary's Island. The island—which was formerly much intersected by creeks, and nearly covered at high water—has been raised about 8 feet by spreading on it the earth excavated out of the basins, &c. Convict labour was employed for the purpose. The whole island will be surrounded by a sea wall and embankment 9,200 ft. or nearly two miles in length, the greater portion being executed by convict labour.

There are three basins :—

1. The "Repairing Basin," covering 21 acres, in which ships are completed after being launched, or are repaired.
2. The "Factory Basin" (shown in the model), covering 20 acres, into which ships are taken to have their engines and boilers put into them. This basin was commenced by prisoners in June 1869, and finished in December 1871.
3. The "Fitting-out Basin," at which the prisoners are now at work, covering 28 acres. Ships will be rigged, and receive their guns, stores, and coals in this basin.

} Total wet dock accommodation 69 acres.

The "Repairing Basin" is 700 ft. wide, a width determined by the space necessary for the largest ship to turn in, when the wharves are occupied by other vessels. It has four docks, each 469½ ft. long and 109 ft. wide. These are capable of holding the largest ship ever contemplated for the Royal Navy, or any ship in the world, except the "GREAT EASTERN." The depth of water in the basin and docks is 36 ft. at spring-tides.

The bricks for the whole of these works, nearly 117,000,000 in number up to date (1877), have been made by convict labour, which has also executed the carpenters', blacksmiths', bricklayers' and other trades, necessary in the construction of the works.

The model contains the figures of 295 prisoners, 40 superior and subordinate officers, and 14 free-men; the last-named were formerly employed as engine drivers and stokers, but these duties also are now performed by prisoners. There were, however, a considerably larger number of prisoners at work in the construction of this basin than is shown on the model; and the daily average number of prisoners employed annually on the Admiralty works is 1,130.

12. MODEL. The iron floating dock at the Island of St. Thomas, West Indies. Carries a ship 3,000 tons burthen. Constructed by the St. Thomas' Island Floating Dock Company.

Lent by Mr. E. Hodges, 25, Abchurch Lane, E.C.

1878.

13. WATER-COLOUR DRAWING. Iron floating dock, designed by F. J. Bramwell, and constructed, 1867 by N. Scott Russell, Bute Ironworks, Cardiff, for the Island of St. Thomas, West Indies.

Transferred from the Patent Museum. 1886.

Note.—The length of this floating dock 300 ft., width 100 ft., height 42 ft. 3 ins. In the winter of 1867 the dock was accidentally sunk. In July 1870 it was raised, but had a severe list to one side so that it was not fairly floated again until January 1871.

14. DRAWING. Lithograph, framed and glazed. The new harbour and docks at Newhaven. F. D. Bannister, Engineer.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

15. DRAWINGS, COLOURED LITHOGRAPHS, and PHOTOGRAPHS. Clark, Standfield, and Company's patent floating and depositing docks; and gripping camels for raising sunken vessels.

Lent by Messrs. Clark, Standfield, & Co., 6, Westminster Chambers, S.W. 1878.

16. MODEL. Working model of a double power floating dock; with model of screw steamship for illustration.

Lent by Messrs. Clark and Standfield, 6 Westminster Chambers, S.W. 1879.

Note.—The special feature proposed in this dock is that the dock should dock itself for overhaul and repair to avoid careening it over or running it ashore for the purpose.

17. MODEL. Sunken ship raising apparatus, and floating dock. Sectional model portion of iron built ship.

Lent by Mr. D. Halpin, 10, Victoria Chambers, Victoria Street, Westminster. 1879.

18. LITHOGRAPH, illustrating methods of raising sunken ships and wrecks, by means of Messrs. Siebe, Gorman, and Christy's ship-raising iron pontoon. Messrs. Siebe and Gorman, Submarine Engineers, Denmark Street, Soho.

Presented by Messrs. T, Christy & Co., 155 Fenchurch Street, E.C. 1873.

19. WHOLE MODEL. Steam floating crane "ATLAS." Constructed to lift 100 tons.

Lent by Sir Wm. Armstrong, Mitchell, & Co., Newcastle-on-Tyne. 1887.

Note.—The twin-screw steam barge "ATLAS" was built in 1885 for the Mersey Docks and Harbour Board.

Displacement 780 tons. Speed 5 knots. This crane will lift 100 tons at a radius of 30 ft., and 30 tons at a radius of 47 ft. The counterbalancing is regulated by water ballast.

For other models lent by Armstrong, Mitchell, & Co., see pages 12, 14, 90.

20. WORKING MODEL, on a scale of ½ in. to 1 ft. Hunter's steam floating crane, to lift 50 tons with an all round radius of 47 feet.

Constructed 1885 for the East and West India Dock Company, Tilbury Docks.

Messrs. Hunter and English, London. 1885.

Note.—The framing of the crane is constructed of wrought-iron plates and angle-iron, and the jib, which consists of two members circular in section, is made of steel. The crane rests upon cast-steel rollers, running upon a curb 26 ft. in diameter, this curb being supported by a wrought-iron cylinder built into the hull.

The movable counterpoise ballast is supported upon the superstructure of the crane, and is always exactly opposed to the load.

The vessel is fitted with twin-screw propellers. Speed 4½ miles per hour.

21. PHOTOGRAPH. Hunter's steam floating crane, to lift and swing 30 tons at 47 ft. radius.

Constructed, 1881, for the London and St. Katherine Dock Company.

Messrs. Hunter and English, London. 1885.

22. PHOTOGRAPH. The floating steam dredger "TILBURY," 30 nominal horse-power.

Constructed, 1884, for the East and West India Docks Company.

Messrs. Hunter and English, London. 1885.

Note.—This floating steam dredging machine was designed to excavate to and maintain a depth of 45 ft. of water.

23. PHOTOGRAPH. The steam floating dredger "ROTHER."

Designed and constructed, 1881, for the Commissioners of the Rother Level.

Messrs. Hunter and English, London. 1885.

Note.—The dredger was designed to excavate to and maintain a depth of 10 ft. of water, and was fitted with special delivery arrangements by which the dredged material was discharged ashore at a distance of 120 ft. from the bank of the River Rother.

24. MODEL. Steam float, moored in the stream. Fitted with machinery, &c., for rapidly discharging the cargoes of colliers and other vessels. William Cory's patent, 1861.

Contributed. 1862.

Transferred from the Patent Museum. 1885.

Note.—This model represents a floating stage or landing-place for vessels requiring to discharge rapidly their cargoes, specially coal, in mid-stream, avoiding all docking work.

The float is to be seen at work on the Thames and other commercial rivers. A few hours suffice to discharge a heavy cargo of coals from screw propeller steam colliers.

25. MODEL. The slipway and ship repairing and engineering works of the Wallsend Slipway Company, Newcastle-on-Tyne.

The Wallsend Slipway and Engineering Company. 1882.

Note.—The slipway will haul up for repair a ship 330 ft. long, equal in gross register tonnage to a vessel of 2,800 tons.

26. HALF BLOCK MODEL. Hopper barge to carry 1,000 tons soil. Built of iron, 1864, at Drogheda, for the Dublin Port and Docks Board. Length 145 ft., breadth 33 ft., depth 15 ft.

Lent by Messrs. Thomas Grendon & Co., Drogheda. 1888.

Note.—The barge is not self-propelling, but is towed out to sea, and is emptied through eight hoppers in her hull bottom. She is stayed fore and aft, bow girder fashion, and is divided into compartments.

For other models lent by Thomas Grendon & Co., see pages 67, 68, 82.

SHEERS FOR MASTING AND FITTING SHIPS.

29. MODEL of the jetty, and sheers for masting ships. Sheerness Dockyard. 1864.

30. MODEL of sheers for masting and fitting ships. Constructed by Messrs. Day, Summers, & Co., Southampton.

Messrs. Day, Summers, & Co. 1876.

Note.—The sheers have three hollow legs constructed of wrought-iron boiler plate, and are controlled and manœuvred by steam power.

CLASS VII.

Paintings, Drawings, Photographs, of Ships, and of Subjects in connexion with them.

OIL AND WATER COLOUR PAINTINGS.

1. STERN VIEW of H.M.S. "ROYAL GEORGE," 1st rate, 100 guns, length 178 ft. 0 in., breadth 51 ft. 9½ in., depth 21 ft. 6 in., tonnage 2,041. Laid down at Woolwich Yard in 1746, launched in 1756, overset 29th August 1782, "she "being heeled to come at the pipe that leads to the well."
The complement of men was 850.
Drawn by Josh. Williams, painted by Josh. Marshall, 1774.
Presented by Her Majesty. 1864.

2. BOW VIEW of H.M.S. "ROYAL GEORGE" (same ship as the preceding).
Drawn by J. Binmer, painted by Josh. Marshall, 1774.
Presented by Her Majesty. 1864.

3. STERN VIEW of H.M.S. "VICTORY," 1st rate, 100 guns, length 174 ft. 9 ins., breadth 50 ft. 6 ins., depth 20 ft. 6 ins., tonnage 1,921. Built at Portsmouth Yard in 1737. Lost in the English Channel in the night between the 4th and 5th October 1744, when Admiral Balchin and the crew of upwards of 1,000 men perished.
Drawn by Josh. Williams, painted by Josh. Marshall, 1744.
Presented by Her Majesty. 1864.

4. BOW VIEW of H.M.S. "VICTORY," (same ship as the preceding).
Drawn by J. Binmer, painted by Josh. Marshall, 1774.
Presented by Her Majesty. 1864.

5. STERN VIEW of H.M.S. "BARFLEUR," 2nd rate, 90 guns, length 177 ft. 8 ins., breadth 50 ft. 5 ins., depth 21 ft., tonnage 750. Laid down at Chatham Yard in 1762, launched in 1768, broken up in 1819.
The complement of men was 750.
Drawn by Josh. Williams, painted by Josh. Marshall, 1774.
Presented by Her Majesty. 1864.

6. Bow View of H.M.S. "Barfleur" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

7. Stern View of H.M.S. "Royal Oak," 3rd rate, 74 guns, length 168 ft. 6 ins., breadth 46 ft. 9 ins., depth 20 ft., tonnage 1,606. Laid down at Devonport Yard in 1766, launched in 1769, broken up in 1815.

The complement of men was 650.

Drawn by Josh. Williams, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

8. Bow View of H.M.S. "Royal Oak" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

9. Stern View of H.M.S. "Intrepid," 3rd rate, 64 guns, length 159 ft. 6 ins., breadth 44 ft. 5 ins., depth 19 ft., tonnage 1,374. Laid down at Woolwich Yard in 1767, launched in 1770, sold in 1828.

The complement of men was 500.

Drawn by Josh. Williams, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

10. Bow View of H.M.S. "Intrepid" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

11. Stern View of H.M.S. "Portland," 4th rate, 50 guns, length 146 ft., breadth 40 ft. 6 ins., depth 17 ft. 6 ins., tonnage 1,044. Laid down at Sheerness Yard in 1767, launched in 1770, sold in 1807.

The complement of men was 350.

Drawn by Josh. Williams, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

12. Bow View of H.M.S. "Portland" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1774.

Presented by Her Majesty. 1864.

13. STERN VIEW of H.M.S. "EXPERIMENT," 4th rate, 50 guns, length 140 ft. 9 ins., breadth 38 ft. 8½ ins., depth 16 ft. 7 ins., tonnage 923. Laid down at Messrs. Adams & Co.'s yard, on the Thames, in 1772, launched in 1774. Dismasted in a gale of wind, and taken the 22nd September 1779 by the French fleet, on her passage from New York to Savannah.

The complement of men was 300.

Drawn by Josh. Williams, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

14. BOW VIEW of H.M.S. "EXPERIMENT" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

15. STERN VIEW of H.M.S. "AMBUSCADE," 5th rate, 32 guns, length 126 ft. 3 ins., breadth 35 ft. 1¾ ins., depth 12 ft. 2 ins., tonnage 684. Laid down at Messrs. Adams & Co.'s yard, on River Thames in 1771, launched in 1773. Taken by the "BAYONAISE" in December, 1798, afterwards retaken and broken up in 1813.

The complement of men was 220.

Drawn by Josh. Williams, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

16. BOW VIEW of H.M.S. "AMBUSCADE" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall.

Presented by Her Majesty. 1864.

17. STERN VIEW of H.M.S. "ENTERPRIZE," 6th rate, 28 guns, length 120 ft. 6 ins., breadth 33 ft. 6 ins., depth 11 ft., tonnage 594. Laid down at Deptford Yard in 1771, launched in 1774, broken up in 1807.

The complement of men was 200.

Drawn by Josh. Williams, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

18. BOW VIEW of H.M.S. "ENTERPRIZE" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

19. STERN VIEW of H.M.S. "SPHINX," 6th rate, 20 guns, length 108 ft., breadth 30 ft., depth 9 ft. 8 ins., tonnage 429. Laid down at Portsmouth Yard in 1773, launched in 1775. Taken by the French in 1779. and retaken in December 1779 by the "PROSERPINE." Broken up at Portsmouth in 1811.

The complement of men was 160.

Drawn by Josh. Williams, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

20. BOW VIEW of H.M.S. "SPHINX" (same ship as the preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

21. STERN VIEW of H.M.S. "KINGFISHER," sloop, 14 guns, length 98 ft. 8½ ins., breadth 26 ft. 10 ins., depth 12 ft. 10 ins., tonnage 302. Laid down at Chatham Yard in 1769, launched in 1770, burnt at Rhode Island, 30th July 1778.

The complement of men was 125.

Drawn by Josh. Williams, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

22. BOW VIEW of H.M.S. "KINGFISHER" (same ship as preceding).

Drawn by J. Binmer, painted by Josh. Marshall, 1775.

Presented by Her Majesty. 1864.

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23. TWO PAINTINGS of ships on copper. These paintings were used in the Royal Nursery, for the instruction of Prince William Henry, afterwards King William IV.

Presented by Mr. F. A. B. Bonney. 1865.

24. TWO OIL PAINTINGS of the "GREAT BRITAIN," at "Low water" and "High water," by J. Walter, 1847.

Lent by Capt. Claxton, R.N. 1865.

Note.—The "GREAT BRITAIN," 3,500 tons. Iron screw steamer, built at Bristol, July 1843, from designs from I. K. Brunel; ran ashore in Dundrum Bay, Ireland, in September 1846, was exposed 11 months, and nearly submerged at every high tide; the sea in south-westerly and southerly gales making a clear breach all over her.

The breakwater here represented, combined with the "GREAT BRITAIN'S" admirable build, saved the vessel. The design for the breakwater was Brunel's, it consisted of 8,000 large faggots, 3 ft. in diameter and 12 or 13 ft. long, placed about the stern and exposed quarter, loaded with stones, and backed by two rows of birch trees, about 60 ft. long. Brunel also designed the engines of the ship, and the gearing to drive the screw.

The "GREAT BRITAIN" was got off by Captain. Claxton, R.N., in 1847–8.

25. PAINTING,—BATTLE OF LEPANTO, Oct. 7, 1571. The great naval engagement between the combined fleets of Spain, Venice, Genoa, Malta, and Pius V.; and the whole maritime force of the Turks. By Bonaventura Peters.
Lent by Mr. T. Dyer Edwardes. 1865.

26. PAINTING,—BATTLE OF SOLEBAY, May 28, 1672, fought between the fleets of England and France on one side, and the Dutch on the other, the former commanded by the Duke of York, afterwards James II.
Lent by Mr. T. Dyer Edwardes. 1865.

27. BATTLE of the DOGGERBANK, in 1781, between the English and Dutch fleets. By T. Luny. 1781.
Lent by Mr. T. Dyer Edwardes. 1865.

28. MEN-OF-WAR IN PORT, by Anderson (b. 1757, d. 1837).
Lent by Mr. T. Dyer Edwardes. 1865.

29. SHIPPING, by Wimont. Painting.
Lent by Mr. T. Dyer Edwardes. 1865.

30. MALTESE GALLEY. Painting.
Lent by Mr. T. Dyer Edwardes. 1865.

31. OIL PAINTING of a Dutch man-of-war. By A. Stork.
Lent by Mr. T. Dyer Edwardes. 1868.

32. OIL PAINTING of an action between Maltese and Algerine vessels. By Vanvitelli, 1647–1736.
Lent by Mr. T. Dyer Edwardes. 1868.

33. OIL PAINTING of Maltese men-of-war at anchor. By Vanvitelli, 1647–1736.
Lent by Mr. T. Dyer Edwardes. 1868.

34. PICTURE of Dutch men-of-war. By Johannes Coesermans.
Lent by Mr. T. Dyer Edwardes. 1868.

35. Oil Painting of Dutch shipping. By Van Ass.
Lent by Mr. T. Dyer Edwardes. 1868

Engravings and Drawings.

37. Series of Engravings (23 in number, framed), illustrating ships-of-war of early periods and of various countries.
Presented by Mr. T. Dyer Edwardes. 1868.

The principal engravings are—

An English second-rate ship-of-war of the smaller class. 1670.

A French second-rate. 1670.

A Spanish second-rate. 1670.

A Dutch second-rate. 1670.

The English fleet. 1342.

A Dutch ship-of-war.

Three English vessels. Ships-of-war. The "Great Harry," 1503; the "Royal James"; the "Royal George," 1756.

A wicker boat of the ancient Britons.

The English war ship "Henri Grace a Dieu," 1520. 1,000 tons burthen.

The other engravings represents ships of ancient Rome, Maltese and Italian galleys, fire ships, &c.
Presented by Mr. T. Dyer Edwardes. 1868.

38. Paintings in Oil. A launch at Deptford Dockyard. English, middle of the 18th century. By J. Cleveley.
Purchased. 1867.

39. The American packet ship "Warren" under jury masts and temporary rudder. These were fitted after her own had been carried away by a storm in the Mid-Atlantic, and enabled her to reach England in safety.
Painted by Mr. George Mears. 1868.

40. Pencil Drawing of the hull of the man-of-war, "Sovereign of the Seas," built 1635 by Mr. Peter Pett. William Van de Velde (b. 1663, at Amsterdam, d. 1707).
Presented by Mr. George Smith. 1865.

41. A Drawing of the port disposition of the frame of H.M.S. "Amethyst," wrecked in Bovesand Bay, Plymouth

Sound, in 1811. Her top side timbers had been continuously bolted, when last repaired according to the plan proposed by the late "Joseph Tucker," Esq., Surveyor of the Navy, and after having been 21 days on the rocks during a gale of wind, she was floated off to Plymouth with unbroken sheer.

Presented by Mr. John Scott Tucker. 1865.

DRAWINGS &c. The following (15), lent by the late Mr. John Scott Russell, F.R.S., are all of ships built by him.

43. LONGITUDINAL DRAWING of the "GREAT EASTERN," steamship. Built 1857.

Lent by Mr. J. Scott Russell. 1868.

Note.—This drawing, on a scale of $\frac{1}{8}$ in. to 1 ft. gives a longitudinal through section of the ship, showing the interior arrangements throughout.

44. DRAWING, cross section of the "GREAT EASTERN" steamship.

Lent by Mr. J. Scott Russell.

45. WATER-COLOUR DRAWING of the "GREAT EASTERN" steamship, off the Isle of Wight.

Lent by Mr. J. Scott Russell.

46. OIL PAINTING of the "GREAT EASTERN" steamship, going through the Downs.

Lent by Mr. J. Scott Russell.

47. OIL PAINTING of the "GREAT EASTERN" steamship, leaving the river Medway, off Sheerness.

Lent by Mr. J. Scott Russell.

Note.—The "GREAT EASTERN" steamship was laid down in 1852, and launched in 1857, at Millwall. See models, Pages.

48. OIL PAINTING of the Royal West India Mail Company's fleet in Southampton Water.

Lent by Mr. J. Scott Russell.

49. WATER-COLOUR DRAWING of the Sydney and Melbourne Royal Mail Steam Packet Company's paddle steamer "PACIFIC." Tons 1,470. Horse power 500.

Lent by Mr. J. Scott Russell.

50. DRAWINGS of the engines, boilers, and wheels of the Sydney and Melbourne Royal Mail Steam Packet

Company's paddle-wheel steamer "PACIFIC," 500 horse-power.

Lent by Mr. J. Scott Russell.

51. WATER-COLOUR DRAWING of the Prussian man-of-war paddle steamer "DANTZIC." Guns 12. Horse-power 400. Also Prussian frigates.

Lent by Mr. J. Scott Russell.

52. WATER-COLOUR DRAWING of the Prussian paddle gun-boats "NIX" and "SALAMANDER."

Lent by Mr. J. Scott Russell.

53. WATER-COLOUR DRAWING of "DANTZIC," "NIX," and "SALAMANDER," Prussian war ships, at gunnery practice.

Lent by Mr. J. Scott Russell.

54. WATER-COLOUR DRAWING of a four-masted screw steamer.

Lent by Mr. J. Scott Russell.

55. WATER-COLOUR DRAWING of a four-masted sailing ship in a gale of wind.

Lent by Mr. J. Scott Russell.

56. WATER-COLOUR DRAWING of a screw steamer.

Lent by Mr. J. Scott Russell.

57. WATER-COLOUR DRAWING of the launch of a frigate at Millwall.

Lent by Mr. J. Scott Russell.

*** The preceding 15 drawings lent by the late Mr. John Scott Russell, F.R.S. 1868.

58. DRAWING of the Pacific Steam Navigation Company's Royal Mail screw steamship "BRITANNIA." Designed, engined, and built, by Messrs. Laird Brothers, Birkenhead, 1873.

Profile.—Sail draft, longitudinal section.

Plans of spar, main, and lower decks.

Engine and boiler rooms.

Length 399 ft., breadth 43 ft., depth 35 ft. 3 ins. Tons, o.m. 3,670. Horse-power 600. Has accommodation for 748 passengers.

Messrs. Laird Brothers, Birkenhead. 1874.

59. TWO COLOURED ENGRAVINGS of the screw steamship "ARCHIMEDES" at sea, on 14th May 1839. Built in 1839

by Mr. H. Wimshurst, of Limehouse, for "The Ship Propeller Company."

The ship fitted with Mr. Francis Pettit Smith's screw propeller.

Dimensions of ship "ARCHIMEDES" were:—Extreme length 125 ft., extreme breadth 22 ft. 6 ins., depth 13 ft., tons 240, draught of water 10 ft. aft., 9 ft. forward. The engines were of 80 horse-power. Diameter of screw, 5 ft. 9 ins., length of screw 5 ft. Screw was driven by vertical engines and multiplied wheel gearing.

The drawings show also profile of the ship.

Mr. Henry Wimshurst. 1873.

60. TWO COLOURED DRAWINGS of the first screw steamship "ARCHIMEDES" on her voyage from London to Portsmouth in May 1839.

Presented by the late Vice-Admiral E. P. Halsted, R.N. 1868.

61. TWO COLOURED DRAWINGS. Screw steamship "ARCHIMEDES," on her voyage from London to Portsmouth, in May 1839.

Lent by Mrs. Bennet Woodcroft. 1876.

62. DRAWING. Pen and ink. Port and starboard view of the figure-head of H.M.S. "WINDSOR CASTLE." Drawn by Mr. Nicholas Rundell, 1840.

Presented by Mr. J. B. Rundell. 1874.

63. PICTURE of the "RAINBOW," 1837. Iron paddle steamer. Length 185 ft., breadth 25 ft., depth 11 ft. 9 ins., 581 tons, 180 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note. The paddle steamer "RAINBOW" for passenger and cargo service was built for the General Steam Navigation Company of London, for service between London and Ramsgate. After being employed in London and Antwerp trade for some time, the "RAINBOW," which was the fastest vessel of her day, ran for many years as a cargo steamer between Havre and London, and was in service till 1869.

She was fitted with a pair of upright engines known as "Steeple" engines, at one time greatly used for paddle-wheel steamships.

64. PICTURE of the ferry steamer "NUN." 1844. Paddle-wheel. Length 105 ft., breadth 20 ft., depth 8 ft. 9 ins., 187 tons, 60 horse-power.

Messrs. Laird Brothers, Birkenhead. 1876.

Note.—The picture shows the "NUN" grounded on the stone pier at Birkenhead, her after end resting on the pier, and her bow on the bare rock below, the distance between the points of support being 81 ft.; the whole weight of the machinery, 65 tons, being in the middle of this unsupported space. She floated off the succeeding tide without having received the slightest damage.

This incident, which occurred in 1842, went far to confirm the growing confidence in the strength of iron ships.

65. THREE DIAGRAMS of new type of war ships, designed by Michael Scott in 1870.

Mr. Michael Scott, F.R.S.E., London. 1876.

Note.—In this design there is a central fort, armour plated all round; an armoured deck under water sloping downwards towards the bow, so as to prevent the vessel from being raked in a seaway, and strengthening the ramming beak. The ship is intended to carry sail, her turrets to be placed abreast and also to carry broadside guns.

Some of the most important features in these designs have been adopted in the most modern war ships.

66. THREE DIAGRAMS of a new type of war ship, designed by Michael Scott in 1869, and published in 1870.

Mr. Michael Scott, F.R.S.E., London. 1876.

Note.—In this design the surface exposed to hostile fire is diminished by constructing the vessel with a central fort, armour plated all round, an armoured deck under water, and dividing the space above this armoured deck for a height of 6 ft. into water-tight compartments, which would be filled with fuel or water when going into action. She is intended to carry both turret and broadside guns, and might be armed with a submarine weapon.

67. DRAWING on cloth, for lecture purpose. Steamboat designed in 1737 by Jonathan Hull, Engineer.

Sir F. J. Bramwell, F.R.S. 1877.

Note.—Jonathan Hull claimed for his steamboat the power of moving against tide and wind, and of towing against them ships-of-war and other large vessels. There is an old work published, with an engraving of this steamboat at work, and the drawing is a copy of the engraving.

68. OIL PAINTING. The screw steamship "CITY OF RICHMOND," under sail and steam. Inman line ship. Liverpool to New York. Built 1874, by Tod and MacGregor, now D. and W. Henderson & Co., Glasgow; horse-power 900.

Lent by Mr. S. E. Slader, 9 Magdala Terrace, Dulwich. 1879.

Note.—Length of ship 450 ft., breadth 43 ft., depth 36 ft. Compound engines, cylinders 76 and 120 ins. diameter, stroke 5 ft., boilers 10, furnaces 30.

69. LITHOGRAPH. Coloured Lithograph of the Mississippi and Dominion (of Canada) Steamship Company's steel screw steamship "VANCOUVER," 1882. Gross registered tons 5,700. Messrs. Charles Connell & Co., Glasgow, constructors. The engines and machinery by John and James Thomson, Engineers, Glasgow.

Messrs. Flinn, Main, and Montgomery, Liverpool.
1882.

70. PHOTOGRAPH of an old drawing representing the wooden twin-hull steamboat "PRINCESS CHARLOTTE." Built in 1816 at Piehelsdorf near Spandau, Germany, by John Rubie and John Barnet Humphreys, English Engineers.

Mr. C. P. Rubie. 1876.

Note.—The "PRINCESS CHARLOTTE," double-hull steamer, with one paddle wheel between them amidships, was built for the navigation of the rivers Elbe, Havel, and Spree. She began to run in November 1816, and was the first steamer put together or built in Germany. The engine of 14 horse-power was made by Messrs. Bolton and Watt. The drawing represents the ship as lying at "Die Zelten," Berlin. Her length was 130 ft. 5 ins., width 19 ft. 4 ins., tons 236 B.M.

71. SIX PHOTOGRAPHS, presented, 1869, by Messrs. R. Napier and Sons, Glasgow, of ships built by them, as follows:—

1. H.M.'s iron screw troopship "MALABAR." Built and engined, 1867, by R. Napier and Sons. Length 360 ft., breadth 49 ft., depth 22 ft. 4 ins., tonnage 4,173, horse-power 700. See Model of H.M.S. "JUMNA," Class I., p. .
2. Armour clad monitor "DE TYGER." Built 1868 by R. Napier and Sons, for the Royal Dutch Government. Length 187 ft., breadth 44 ft., depth 11 ft. 6 ins., tonnage 1,612, horse-power 140.
3. Armour-clad monitor "DE BUFFEL." Built 1868 by R. Napier and Sons, for the Royal Dutch Government. Length 205 ft., breadth 40 ft., depth 24 ft., tonnage 1,472, horse-power 400; twin screw.
4. Iron-clad screw frigate, "OSMAN GHAZY," and others on same lines. Built 1866 by R. Napier and

Sons, for the Imperial Ottoman Government. Tonnage 4,221, horse-power 900.

5. Screw steamships "PEREIRE," and "VILLE DE PARIS." Built 1866 by R. Napier and Sons, for the French "Compagnie Générale Transatlantique." Length 357 ft., breadth 44 ft., depth 29 ft., tonnage , horse-power 800, speed 15 knots.

6. Steam screw yacht, schooner rigged, "VAYNOL," Tons B.M. 48, horse-power 20. Built by R. Napier and Sons, 1868.

72. PHOTOGRAPH of the screw steamship "CITY OF NEW YORK" leaving the River Mersey on her voyage to New York. Built, 1866, by Tod and McGregor, Glasgow. J. Walters, Liverpool, photo., 1867.

73. PHOTOGRAPH of the screw steamship "ORION," showing the effect of a collision with another vessel, off Beachy Head, December 21, 1869. Repaired by the London Engineering and Iron Shipbuilding Company (late Westwood, Baillie, and Co.), Isle of Dogs, Poplar, 1870.

Presented by Captain Symonds, R.N. 1870.

74. PHOTOGRAPH of the whole model lent by H.I.H. the Prince Napoleon in 1872 of the Imperial French screw steam yacht "JEROME NAPOLEON." 1873.

75. PHOTOGRAPH of the paddle steamers "COMET," built 1811, and the "IONA," built 1874. Clyde river service vessels.

Mr. John Hamilton, Glasgow. 1876.

Note.—Photographed from a painting by Wm. Clark, Greenock, to illustrate and record a comparison between the earliest and present types of Clyde river steamers.

76. PHOTOGRAPH of the fore topsail, after the battle of Trafalgar in 1805, of Lord Nelson's ship "VICTORY," built 1765.

Presented by Mr. S. Willcocks, Master Sailmaker, H.M. Dockyard, Sheerness. 1868.

77. PHOTOGRAPH. Framed and glazed. The shipbuilding yard and slip dock at Messrs. A. and J. Inglis' Works. Point House, Glasgow.

Presented by Messrs. A. and J. Inglis. 1879.

78. Set of PHOTOGRAPHS (four in number).
Two, of R. R. Bevis' patent feathering from inboard screw propeller, fitted to screw steam yacht "KATHLEEN," by Laird Brothers.
Messrs. Laird Brothers, Birkenhead. 1873.

79. PHOTOGRAPH. The American Line Steamship Company's iron screw steamers "PENNSYLVANIA," "OHIO." "INDIANA," and "ILLINOIS." Tons, 3,104. Horse-power, 600. The steamships were built and engined in America.
Presented by Colonel Sir Herbert Sandford, C.B. 1878.

80. PHOTOGRAPHS. A series, 104 in number. Views in the Arctic regions during the Expedition of H.M.S. "DISCOVERY" and "ALERT," 1875–6.
Purchased. 1878.

Note.—The photographs have been transferred to the Science Library.

81. COLOURED ENGRAVING (Lithograph) of the Admiralty Department Buildings, Whitehall, in 1808.
Published by Ackerman & Co., Strand.
Presented. 1876.

82. Series of DRAWINGS and PHOTOGRAPHS illustrating steam donkey engines, winches, pumping engines, cranes, and fresh-water distilling apparatus, &c.
Presented by Messrs. Alexander Chaplin & Co. Glasgow. 1874.

Drawing on a 1 in. to 1 ft. scale of steamships' winding engine, with distilling apparatus for fresh water, and steam cooking hearth.

Drawing on 6 ins. to 1 ft. scale of an improved donkey steam engine for feeding steam boilers with water.

Drawing on 1½ in. to 1 ft. scale of a ship's improved steam winch.

Drawing on a 1½ in. to 1 ft. scale of Messrs. Chaplin & Co.'s patent vertical steam boiler.

Photograph of a steam winding and pumping engine.

Photograph of a steam crane.

Photograph of a single cylinder hoisting engine.

Photograph of a winding and pumping engine.

Photograph of a contractor's locomotive engine.

Photograph of a travelling fresh-water distilling apparatus.

83. DRAWING on a scale of 1 in. to 1 ft. Newcomen's pumping engine. About 1760. From the original working model at the University of Glasgow.

Lent by Mr. T. Lidstone. 1877.

Note.—The original model of Newcomen's engine, the property of the University of Glasgow, is a working model having boiler, steam cylinder, rocking beam of wood, piston and connecting rod, and pump rod. Newcomen devised this engine for pumping water from mines in the latter part of the 18th century.

The model was lent to the Exhibition of Scientific Apparatus held at South Kensington, 1876. In 1765 it was repaired for the university by James Watt, at this time reputed for his skill in repairing steam engines. The many defects observed by Watt in the working of this engine led to the great improvements he effected in the detail of the steam engine, in which also the researches on the subject of heat, made by Dr. Joseph Black, born 1728, died 1799, Professor at Glasgow University, 1756, greatly assisted Watt.

In the collection are two photographs representing a right and left view of the model.

84. PHOTOGRAPH. An old engraving by T. Barney, 1719, representing Captain Savery and Mr. Newcomen's steam engine, erected near Dudley Castle, Staffordshire, 1712.

Presented by Mr. R. L. Galloway. 1880.

Note.—The photograph is on a reduced scale from the original engraving. It is extremely interesting—historically. Copious reference is given to the detail and working of the engine.

85. PHOTOGRAPHS (set of five), showing the operations of raising the Orient Steam Navigation Company's steam ship "AUSTRAL," sunk whilst coaling in Sydney Harbour, Australia, November 1882, and raised again in March 1883.

Presented by Colonel Sir Herbert Sandford, C.B. 1883.

86. WATER-COLOUR DRAWING, framed and glazed. A sailing frigate of 51 guns, under weigh in heavy weather; with other steam and sailing vessels in the offing.

Painted and presented by Mr. W. F. Settle.
Transferred from Art Museum. 1884.

87. SIX WATER-COLOUR Drawings of early paddle-wheel and screw propeller vessels :—

1. Paddle steamer "CHARLOTTE DUNDAS." W. Symington's steam machinery, 1803.

2. Double-hull pleasure steamboat paddle. Patrick Miller, W. Taylor, and W. Symington, 1788–9.
3. Double-hull ship. Driven by paddle-wheels. Designed by Patrick Miller, Dalswinton, 1787.
4. Early steamboat. Possibly the "CLAREMONT." Name not known precisely.
5. Screw steamer, possibly the "NEW JERSEY." Ericsson, 1839–40. Schooner rigged, under steam and sail.
6. Paddle steamer, "COMET." J. and C. Ward Glasgow, 1811.

Lent by Mrs. Bennet Woodcroft. 1876.

88. COLOURED DRAWING. Details of William Symington's paddle-wheel steam engine, 1787.

The steam and exhaust valve motion, condenser, steam cylinders, pistons and piston rods, the connecting and driving gear of the wheels.

Lent by Mrs. Bennet Woodcroft. 1876.

89. DRAWING, not coloured. Details of Symington's engine.

The steam and exhaust valve motion, condenser, steam cylinders, pistons and piston rods, the connecting and driving gear of the wheels.

Lent by Mrs. Bennet Woodcroft. 1876.

90. COLOURED DRAWING. Elevations, side and end, and plan, of Wm. Symington's marine engine, 1787.

Lent by Mrs. Bennet Woodcroft. 1876.

91. COLOURED DRAWING (isometrical projection.) Paddle-wheel steam engine, constructed 1787–8, by Wm. Symington for Patrick Miller, Esq., and used to drive Miller's boat on the lake at Dalswinton, N.B., 1787.

Lent by Mrs. B. Woodcroft. 1876.

92. WATER-COLOUR DRAWING. Steamer. Stern-wheel paddle boat. Driven by a single horizontal engine, condensing. James Watt, 1769.

The paddle-wheel driving motion. James Pickard, 1780.

The vessel steered from the fore end. W. Symington's plan, 1802.

The paddle-wheel is housed or boxed.

The rudder is abaft the paddle-wheel and carried on a rudder post set up on the prolonged keel of the boat.

Lent by Mrs. Bennet, Woodcroft. 1876.

99. THREE COLOURED DRAWINGS. (In one frame.)
Marine engine. James Watt, 1769.
Paddle-wheel driving motion. James Pickard, 1780.
Paddle-wheel. Patrick Miller, 1787.
Lent by Mrs. Bennet, Woodcroft. 1876.

100. COLOURED DRAWING. H.M.'s screw-propeller steamship "DWARF," 1840. Built by J. and G. Rennie. Fitted with variable pitch screw propeller, by Bennet Woodcroft, 1843.
The drawing also shows details of the propeller.
Lent by Mrs. Bennet Woodcroft. 1876.

101. PENCIL SKETCH. Two screw propellers, designed by Alexander Nasmyth, 1819.
Lent by Mrs. Bennet Woodcroft. 1876.

Note.—The drawing represents the screw propeller in front of the rudder, and to be driven by direct action from the engine. Nasmyth states that his propellers were to drive vessels on water by steam power or otherwise.

102. DRAWING. Details of a steamboat designed and built, 1783, by the Marquis de Jouffroy, at Lyons, for service on the Sôane.
Lent by Mrs. Bennet Woodcroft. 1876.

Note.—The steamer represented was 140 ft. long, 15 ft. wide, and drew 3·2 ft. of water. She was driven by a horizontal, single-cylinder steam engine, her paddle-wheels moved with a jerking action, due to the in and out strokes of the engine which moved an iron frame backward and forward, having on the top and bottom bars double sets of pauls; on the paddle shaft which ran through the frame were two fixed cam-wheels. In the outstroke of the engine the cam-wheels were pushed by the pauls on the top of the frame, and in the instroke were pulled by those on the bottom, causing an intermittent rotation to be imparted to the paddle-wheels.

103. PEN-AND-INK DRAWING. Longitudinal section of the original steamboat built by Patrick Miller, 1786–7, fitted with W. Symington's marine steam engine, 1788.
Lent by Mrs. Bennet Woodcroft. 1876.

104. COLOURED DRAWING. Details of the triple-hull, paddle-wheel vessel, "EDINBURGH." Invented by Patrick Miller, and launched at Leith, October, 1786.
Lent by Mrs. Bennet Woodcroft. 1876.

Note.—The "EDINBURGH" was the outcome of Patrick Miller's persevering experiments with paddle-wheels. Her

wheels were driven from the upper deck by manual labour at cranks. She was square rigged for sailing with fair winds, and carried both merchandise and passengers.

105. COLOURED LITHOGRAPH. H.M.'s sloops "RATTLER" and "ALECTO," towing stern to stern. For the purpose of testing the relative powers of the screw-propeller and the paddle-wheel.

Lent by Mrs. Bennet Woodcroft. 1876.

Note.—The "RATTLER" was a vessel of 888 tons and built 1843. She was fitted with Maudslay's double-cylinder engines of 200 horse-power, and Smith's screw propeller.

The "ALECTO," 800 tons, was built 1840–3, and fitted with Seaward's direct-acting engines and the ordinary paddle-wheel.

This trial was in the North Sea during a calm, on the 3rd April, 1845, on which occasion the "RATTLER" towed the "ALECTO" stern foremost at the rate of two miles and eight-tenths per hour; both vessels exerting their full power in opposite directions.

106. LITHOGRAPH, coloured. H.M.S. "BASILISK" (common paddle) and H.M.S. "NIGER" (Smith's screw propeller.) Towing stern to stern for determining the relative powers of the screw-propeller and the paddle-wheel.

Transferred from the Patent Museum. 1886.

Note.—The "BASILISK" was a paddle-wheel vessel of the following dimensions:—Length, extreme, 190 ft., breadth, extreme, 34 ft. 5 ins. Tonnage, 1,030. Armament, 6 guns. Her engines, 400 horse power, were constructed by Miller, Ravenhill & Co.

The "NIGER," fitted with F. P. Smith's screw propeller, was 194 ft. 9 ins. extreme length, and 34 ft. 8 ins. extreme breadth. Tonnage, 1,072. Messrs. Maudslay, Sons and Field constructed the engines which were of 400 horse-power. Armament, 14 guns.

This trial of power between the paddle-wheel and screw propeller took place in the English Channel on 20th June 1849, and lasted one hour, in which time the "NIGER" towed the "BASILISK" at the rate of 1·46 knots per hour.

107. LITHOGRAPH, coloured. "A view of Collect Pond and its vicinity in the City of New York, in 1793;" by J. Hutchings, Long Island, 1846.

Transferred from the Patent Museum. 1886.

Note.—An American print, coloured. On this pond, it is said, ran the first boat propelled by paddle-wheels and screw propeller. The boat was constructed by John Fitch six years before Robert Fulton made trial of his boat upon the river Seine, in France, and ten years prior to his putting into operation his boat "CLERMONT," at New York.

108. DRAWING, coloured. Side elevation of a screw-propeller steam vessel fitted with three masts, and rigged fore and aft, stay sail fashion.

Transferred from the Patent Museum. 1886.

109. TWO DRAWINGS, coloured. Scale ½ inch to 1 foot. Portuguese Fishing Boat. "Moleta de Pesca." Length 40 feet; beam 12 feet.

Presented by Mr. G. C. Mackrow, Orchard Yard, Blackwall. 1889.

Note.—The type of fishing craft represented by the drawings has been used for some centuries in the Portuguese fishing industry. The rig, masts, spars and sails are peculiar. The boats are furnished to prevent them going to leeward when the nets are down, and can be so manipulated that the boat shall remain broadside to the wind.

110. DIAGRAMS, coloured. Series of nine. Prepared by Professors Goodeve and Shelley for the technical instruction of students in the principles of Marine and other Machinery. Chapman and Hall, Publishers.

Note.—Amongst these diagrams will be found illustrated details of the piston of an 84 in. diameter cylinder of an oscillating cylinder paddle engine, thrust-block for screw propeller shafts, details of feed and other pumps, slide-valves for oscillating cylinder and compound engines, injectors, &c.

111. DIAGRAMS, coloured. Series of sixteen. Prepared by Professor Unwin, for the technical instruction of students in the principles and details of Mechanical Engineering. Chapman and Hall, Publishers.

Note.—Amongst these diagrams will be found working parts of steam engines, couplings, bolt, nut, and rivet work, wheel work, &c.

APPENDIX.

Miscellaneous Objects of the Ship Model Collection connected with Ships and Shipping inapplicable to the Classification adopted for the Catalogue.

APPENDIX.

Up to 1886 the collection of ship models contained illustrations of Ships' Compasses, Chronometers, Logs, Signal Lights, and such like instruments.

In 1887 most of these objects were, by order, transferred to other sections of the science branch of the museum to which they, in the abstract, appertain.

APPENDIX.—GROUP I.

SHIPS' COMPASSES AND BINNACLES.

SHIP'S COMPASS. Self-registering compass. Mr. J. M. Napier.
D. Napier & Sons, Lambeth. 1874.

GIMBOL COMPASS for boats or small craft.
Mr. H. Sandham. 1875.

SHIP'S COMPASS. Self-registering compass, complete, with binnacle, stand, and lights.
Mr. R. Pickwell, Hull. 1883.

THREE DIAGRAMS showing ships' courses. Automatically produced by Pickwell's self-registering compass.
Mr. R. Pickwell, Hull. 1883.

Note.—The screw steamships "PENGUIN" and "FLORA" were run under Pickwell's compasses in 1882. The "PENGUIN" making voyages to and from London and Hull, and the "FLORA" to and from Hull and Hamburg.

SHIP'S COMPASS. Three tracings of diagrams showing the course of ships, produced automatically by Pickwell's self-registering ship's compass.
Mr. R. Pickwell, Hull. 1884.

SHIP'S COMPASS. Moore's "Belfast" compass, fitted complete.
Mr. F. M. Moore, Dublin. 1885.

SHIP'S COMPASS. Meager's polygon and equatorial improved mariners' compass, with code of fog-signals.
Presented by Mr. R. Meager. London. 1885.

Note.—These ships' compasses of old and recent forms are now to be found with similar instruments exhibited in the science section of the museum devoted to physiography.

APPENDIX.—GROUP II.

SHIPS' CHRONOMETERS.

Examples of these instruments for ship's navigation formerly lent to and exhibited in the ship model collection, are now shown in the science section under the group containing similar instruments for precise measurement.

CHRONOMETERS, eight and two day marine chronometers. Fitted complete. Also the movements only.
Mr. Victor Kullberg, 105, Liverpool Road, Islington, N. 1874.

SHIP'S CHRONOMETER (two-day). Fitted complete for ship's use.
Messrs. Charles Frodsham & Co., 84, Strand. 1876.

CHRONOMETER. One-day ship's chronometer, No. 63, by John Arnold & Son. (1744–1799.)
Mr. C. Frodsham, 84, Strand. 1879.

APPENDIX.—GROUP III.

CLINOMETERS.

Clinometers, Barometers, and the like, were formerly in the ship model collection. They will now be found in the science section, under the group physiography.

BERTHON'S bi-fluid Clinometer, for showing the oscillation, pitching, and 'scending of ships, and also their trim.
The Rev. E. L. Berthon, Romsey, Hants. 1867.

APPENDIX.—GROUP IV.

SHIPS' LOGS.

These instruments used for measuring the approximate speed of sailing and steamships under full weigh (way) in their simplest and recent complex forms are considered as transferred to the science section, and are principally in the group physiography.

Logs.

SHIPS' LOGS. Two rotating brass logs, with self-acting mile indices and registers, arranged on Massey's principle.
Mr. L. P. Casella, Holborn. 1874.

Note.—These frictionless propeller logs are of two sorts; one is the older form with a square end or tail, while the other has the improved conical end or tail which prevents the liability of the former to jump out of the water when towed at high speed. Both these logs are made on Massey's patented principles.

Massey's SHIP'S LOG with mile indices to register the distance run.
Mr. Edward Massey, 17 Chadwell Street, E.C.
1876.

Note.—This log is one of Mr. Massey's original patents for ships' logs which register constantly the distance run by ships. The log consists of two parts, one being the rotator or actual log, which is attached to the second part, the mile indices. The rotator in dragging through the water revolves and drives by wheel-work the indices which register permanently the number of miles run.

Massey's frictionless propeller LOG with conical end.
Mr. Edward Massey, 17, Chadwell Street, E.C.
1876.

Note.—This log is designed with a view of overcoming the many faults found in practice to exist in the preceding log. The frictionless propeller log is formed in one piece instead of two distinct parts. The rotation of it is insured by the vanes at the after end, and this rotation drives the indices which registers permanently the distance run. The conical end does away with the liability of jumping from the water in quick sailing.

Massey's hand lead and deep sea SOUNDING MACHINE.
Mr. Edward Massey, 17, Chadwell Street, E.C.
1876.

Note.—This machine consists of two parts: 1, the lead, much of the usual shape, and 2, the index of the number of fathoms passed by the lead. This index has a screw propeller which, forced through the water by the weight of the falling lead, drives an index showing evolutions of the screw. The rotator or screw propeller makes four revolutions in passing through one fathom of water, so that for the number of fathoms the instrument has passed through there will be an equivalent number of revolutions of the rotator, which are indicated by the graduated scales of the register. The

rotator is held fixed in its place by a shield which, both for casting and hauling in, prevents action of the screw either before or after the sounding.

Massey's SOUNDER. An instrument for registering depth in fathoms.

Mr. Edward Massey, 17, Chadwell Street, E.C. 1876.

Note.—This instrument is self-contained in one piece. The rotator or screw which drives the index in passing through the water is protected by a ring guard. The index is divided into fathoms and registers 120, to set which turn the nut on index cover until the word "set" on it is brought to the centre opposite the pointer. In hauling in the rotater is set fast to prevent further action.

SHIPS' LOGS. Massey's. Conical-ended frictionless log and deck log with speed gauge.

Mr E. Massey, 17, Chadwell, Street, E.C. 1879.

The "PENDENT LOG."

Messrs. Cohen, Jacob & Co., Ely Place, Holborn. 1876.

Note.—This log is formed of two parts, one called the rotator, which is the log proper, in the form of a screw, and the other called the register, which gives the number of knots traversed by the ship while the log is thrown out and in action. The apparatus is intended to be used permanently, and should be attached to ship's quarter rather than her stern in order to keep the rotator more out of ship's wake.

Berthon's NAUTACHOMETER or perpetual log, for indicating speed of ships.

The Rev. E. L. Berthon, Romsey, Hants. 1867.

APPARATUS for determining at all times by electric or magnetic means, the latitude, longitude, and speed of a ship at sea. Designed and patented in 1876 by Tito Visino as a hydrograph.

Miss Clough, Park Lodge, King's Road, Clapham Park. 1877.

Note.—The hydrograph is intended to trace, by self-acting mechanism, on a kind of hydrographic map, the course of a vessel, and to register continuously and permanently her speed, movements, and position (latitude and longitude) at any moment by day or night. It consists of three parts. The first being a counting apparatus or log; the second an electro-magnetic needle to act in conjunction with the log; thirdly, a graphic apparatus governed by the log and the electro-magnetic needle, for recording on the hydrographic map the ship's course.

SHIP'S LOG. The "Broad Arrow" log. Mr. B. T. Moore, Teddington.
Presented. 1882.

Note.—In this log the line is attached to a long link which swivels at some distance in rear of the log's head. The head of the log is balance-weighted to prevent "jumping" when in use. The screw propeller tail of the log drives the speed register, the dials of which are covered by a cap when working, and read off holding the log vertical. Two examples of this log may be found in the collections.

SHIP'S LOG. Perpetual log or apparatus for measuring and indicating a ship's speed. Wm. Foxon's patent, 1772.
Presented by Mr. Joseph Taylor 1857.
Transferred from the Patent Museum. 1885.

SHIPS' LOGS, Two. For measuring the speed of ships and taking soundings without heaving to. A. Pécoul's patent, 1854.
Contributed 1858.
Transferred from the Patent Museum. 1885.

Deep-sea SOUNDING APPARATUS. G. C. Wallich's patent, 1860.
Contributed 1861.
Transferred from the Patent Museum. 1885.

SHIP'S LOG. Working dial log, for measuring the speed of ships. Admiral F. Bullock, R.N., patent, 1863.
Presented 1865.
Transferred from the Patent Museum. 1886.

APPENDIX.—GROUP V.

SHIPS' LIGHTS AND SIGNALS.

Signal lights, Ships' lights, will be found in the science section, under the group "Light." Ships' ensigns and signal flags are not now exhibited in the ship model collection.

SHIPS' LIGHTS.

SIGNAL LANTERN, or riding light. Captain Colomb's, R.N., riding light, fitted with improved light apparatus and lantern glass or lense.
Lent by Capt. Colomb, R.N. 1873.

Ships' Ensigns and Signal Flags.

Coloured Chart. British flags.
Presented by Mr. James Reynolds. 1864.

Chart, partly coloured, illustrating the flags of all nations, the rigging and sails of a ship, and varieties of shipping.
Presented by Mr. James Reynolds. 1864.

Appendix.—Group VI.

Armament of Imperial Vessels.

From 1864 to 1887, ships' guns, carriages, fittings, and mountings, of old and recent forms were displayed in the Ship Model Collection. This group has now been suppressed entirely, but a few of the models illustrating early methods of fitting and mounting ships' guns, being valuable historically, may be found.

Projectiles, shot and shell, used in the Navy, were also formerly exhibited, but are now entirely suppressed.

Model, in brass, of an old pattern naval service muzzle-loading smooth-bore gun.
Presented by Rev. J. Hardie, Falmouth. 1866.

Model. Gun fitted, on the inside principle, to H.M.S. "Rapid." Naval service. 1864.

Model. Two guns on the common principle. Naval service. 1836. 1864.

Model. Mode of fitting a 32 pr. gun of 25 cwt. in H.M.S. "Imogen." Portsmouth Yard, 1831. 1864.

Model. One gun on carriage, and two on slides, on the inside principle. Naval service.
Proposed by Mr. J. Edye. 1837. 1864.

Model. Gun and carriage. Naval service. 1864.

Model. Gun and carriage. Naval service. 1864.

Model. Gun and carriage, with one pair of trucks, as fitted to H.M.S. "Daphne," 18 guns. Built 1838. Naval service. 1864.

Model. Gun with carriage, fitted with lever to raise and lower the bed and quoin. Naval service. 1864.

MODEL. Carronade, on the inside principle, as fitted to H.M.S. "LIBERTY," 16 guns. Built. Naval service. 1864.

MODEL. 32-pr. carronade, fitted on the inside principle, with slide shortened for quarter deck. Naval service. 1864.

PORT, with fittings for a carronade on the non-recoil principle. Naval service. 1864.

SHACKLE AND THIMBLE for gun. Proposed for Naval service. 1864.

Wood pattern SHACKLE for gun-breeching. Proposed for Naval service. 1864.

APPENDIX.—GROUP VII.

FLOATING STEAM AND OTHER DREDGING MACHINES.

Ladder dredgers, steam driven and self-propelling. Pole and bag dredgers.

WHOLE MODEL of a harbour steam dredging machine; built of iron, propelled by twin screws, and showing the chief fittings and improvements carried out by the builders, Thomas Wingate & Co.

Messrs. Thomas Wingate & Co., Whiteinch, Glasgow. 1877.

Note.—This model is a working model, so far as the dredging machinery is concerned; being fitted with copper boiler and working engine. It also shows the upper deck arrangements of this kind of vessel which is employed for the heaviest sort of work in harbour dredging.

MODELS. Steam dredging machine, Kinipple's circular steam dredging machine, with hoppers, and Kinipple's patent dredging buckets.

Mr. W. R. Kinipple, Greenock. 1881.

MODEL. Steam dredging machine of ordinary form; fitted with Kinipple's dredger buckets.

Mr. W. R. Kinipple, Greenock. 1881.

MODELS. Brass models of Kinipple's dredger buckets with interchangeable parts, and alterable noses.

Mr. R. W. Kinipple, Greenock. 1881.

Appendix.—Group VIII.

Light Ships. Lighthouses. Coast and Harbour Lights. Mark Buoys.

Whole Model. The light ship stationed on the Goodwin Sands; with lanterns, and all fitments complete, for day and night service. Scale ½ in. to 1 ft.

Note.—The following are the principal dimensions of the Goodwin Sands Lightship:—

Length 96 ft., breadth 21 ft., depth 10 ft. 8 ins. Tons 195.
Height of main globe from water line 58 ft.
Weight of mushroom (anchor) 42 cwt.
Size of chain cable 1⅛ in., length of cable 210 fathoms.
The port side of the vessel shows the ship built complete.
Starboard side shows the timbers, waling, &c.

Lent by the Corporation of the Trinity House. 1865.

Model in Wood of the existing Eddystone Lighthouse, made by George Knott, for many years lightkeeper on the rock.

Lent by the Corporation of the Trinity House. 1866.

Note.—The Eddystone Rocks, so named from the variety of sets of tides and currents which surround them, are situated about 14 miles S.S.W. of the port of Plymouth, the sea being fully 30 fathoms in depth. A lighthouse was constructed on these rocks by Winstanley in 1696, and destroyed by a storm in 1703. A second was built by Rudyerd in 1709, and was totally consumed by fire in 1755. The third lighthouse was commenced in 1755–56, and completed in 1759, by John Smeaton, F.R.S., Civil Engineer. Born 1724, died 1792.

Model of the lighthouse on the Eddystone Rock, off the coast of Cornwall, 1757–1759.

The Corporation of Trinity House. 1874.

Note.—This model represents the lately existing stone lighthouse built on the Eddystone Rock by John Smeaton, Engineer. It was begun in 1756–7 and finished 1759. It now stands on Plymouth Breakwater.

The light (fixed) was first shown on October 21, 1759.

It was found necessary in 1877 to consider the taking down and rebuilding anew on another rock the Eddystone Lighthouse of 1759, owing to the undermining action of the sea upon the rock on which the light stood. The present and new lighthouse was begun in 1879 and completed May 1882. Sir J. N. and W. T. Douglas, Engineers.

MODEL of the Gunfleet Lighthouse. Iron. Built on Mitchell's patent screw piles, of which a model is shown. The piles screw 40 ft. into the sand, and have screws 4 ft. in diameter. James Walker, Engineer.

Lent by the Corporation of the Trinity House. 1874.

MODEL of the lighthouse on the Needles Rocks, Isle of Wight. Built 1857–1858. Light shown January 1, 1859. J. Walker, Engineer, T. Ormiston, Executive.

The Corporation of the Trinity House. 1874.

MODEL of the lighthouse on the Great Basses Rocks, Ceylon. Begun 1870, finished 1872. Shows a revolving red light, giving flashes at 45 seconds interval, at 110 ft. above high-water. Light was first shown March 15, 1873.

Lent by the Corporation of the Trinity House. 1874.

Note.—This lighthouse was built from designs by James N. Douglas, M.I.C.E., under the superintendence of William Douglas, M.I.C.E. The tower is of Scotch granite (Dalbeattie), each stone of which was dressed, fitted, and marked in this country.

MODEL of the lighthouse on the Wolf Rock, coast of Cornwall. Begun 1864, finished 1869. Shows a fixed red light at 119 ft. above high-water. Light first shown January 1, 1871. Sir J. N. Douglas, Engineer.

The Corporation of the Trinity House. 1874.

MODEL of the old lighthouse on the Smalls Rocks, about 17 miles off the coast of Pembrokeshire. Erected 1776; replaced in 1861 by a stone lighthouse. The model is made out of one of the oak piles of the original lighthouse.

The executors of the late Captain Pickering Clarke, R.N. 1862.

BABBAGE'S apparatus for an occulting light in lighthouses.

Major-General Babbage. 1876.

Note.—This piece of mechanism was designed in 1850 by the late Mr. C. Babbage (*b.* 1791—*d.* 1871), with a view of rendering lighthouses disinguishable from one another at sea by night, by means of a given number of flashes of light occulting in a preconcerted order. The number of consecutive flashes counted and their duration would form a means of determining the exact lighthouse seen, and thus mariners would be able to fix accurately the position of their ship

when opposite any line of the coast. Mr. Babbage also invented the celebrated calculating machine known by his name, now exhibited in the Science Division of the Museum.

SERIES OF MODELS, illustrating mark buoys, used by the Trinity House Corporation round the British coast.

The Corporation of the Trinity House. 1874.

Note.—The models are on a scale about 1 in. to 1 ft., and represent iron and wooden buoys with their anchorage. The following are the mark buoys represented by the models:—

A bell buoy, 8 ft.
Egg-bottomed buoy, 12 ft.
Hollow-bottom buoy, Herbert's pattern.
Reversed can, 8 ft.
Convex buoy, wood, 8 ft.
9 ft. can, wood.
8 ft. can, wood.
Wreck buoy, wood.
17 ft. can.
7 ft. can, wood.

COLOURED ENGRAVINGS of Captain E. Bedford's, R.N., uniform code for the distinction of buoys by colour.

Presented by Captain E. G. Bedford, R.N. 1867.

PHOTOGRAPHS illustrating dioptric apparatus for light-houses, by Chance, Brothers, & Co., Glass Works, Birmingham.

Lent. 1875.

First order revolving light, eight sides. For the Longstone, Fern Islands, 1873.

First order revolving light, with alternate red and white flashes of equal intensity; nine sides. For Hartland Point, Devon, 1873. Views showing great lens (69° 28′) for the red flash.

First order revolving light, with alternate red and white flashes of equal intensity; nine sides. For Hartland Point, Devon, 1873. Views showing red shades (69° 28′) for the red flash.

First order revolving light, with six sides (60° each) with subsidiary apparatus (fifth order holophote and totally reflecting prisms) by which a fixed light is exhibited at a lower level. For Start Point, Devon, 1873.

Fourth order condensing light, with fixed apparatus, holophote and vertical prisms. For Cowan, Cowan Point, Queensland, 1874.

Fourth order condensing light, with fixed apparatus, holophotes and vertical prisms. For Cowan, Cowan Point, Queensland, 1874.

First order revolving light, alternate red and white flashes of equal intensity. For the Wolf Rock, coast of Cornwall. Front view of red shades, 1869.

First order revolving light, alternate red and white flashes of equal intensity. For the Wolf Rock, coast of Cornwall. View showing red shades half opened, 1869.

Revolving light (of the second and third order) for the electric spark. For Soutar Point, coast of Northumberland. View showing main apparatus and subsidiary apparatus for the lower light, 1870.

First order revolving light, eight sides. For Boompjes, Java, 1870.

Fourth order revolving light. For the Government of Brazil, 1871.

Third order fixed light, for the electric spark. For South Foreland High Lighthouse. Front view, 1871.

Third order fixed light for the electric spark. For South Foreland High Lighthouse. Back view showing intensifying agents, 1871.

Second order light, 15 sides; exhibiting triple flashes in rapid succession in groups, at intervals of half-a-minute, with new clockwork and centrifugal governor. For Mexico, 1875.

Type of a first order, fixed light. As made for the Trinity House of London. View, with figures, to show scale.

First order fixed light, with vertical condensing prisms. For Bidstone Lighthouse, near Birkenhead. For Mersey Docks and Harbour Board, 1872.

Fifth order fixed lights, with vertical condensing prisms and holophote. For the Port of Dublin, 1872.

Second order revolving light, showing clockwork and lamp. For the Gun-Cay Lighthouse, Bahamas, 1872.

Note upon Lenses and Apparatus for Lighthouses.

Extracted from Information given on this subject by the Lighthouse Service of France, 1876.

First essay.—Echeloned lens, polygonal form. Invented by A. Fresnel, and constructed under his direction in 1819.

First echeloned lens, polygonal form, for flashing lights of the first class. Invented by A. Fresnel, and constructed in 1820.

First echeloned lens, annular form, for flashing lights of the first class. Invented by A. Fresnel, and proceeding from the lenticular apparatus fixed on the tower of Cordouan in 1821.

When Fresnel conceived the idea of substituting in lighthouses for metallic reflectors large glass lenses, he thought of composing these lenses of several pieces, and of calculating the curves of these different pieces so as to rectify their spherical divergence. He demonstrated his plan before the Lighthouse Committee, in August 1819, three months only after his appointment on the Committee, and on the 19th of October following he was granted the sum of 500 fr. for constructing a trial lens. He consulted the optician Soleil, who seconded him with much good will, but who could only put at his disposal the limited appliances then in use. Glass was at this time worked still by hand, and shaped only into plane or spherical forms. Fresnel admitted that the lens should be flat on one side; that the different gradients, instead of forming circular rings, should be defined by polygons and divided into a certain number of pieces, each of which should receive on its echeloned side a spherical surface properly calculated. Another difficulty arose from the glass factories being unable to supply in sufficient size pieces of crown glass free from bubbles and striæ; but Fresnel discovered the way of re-smelting glass without altering its transparency.

He first constructed a trial lens of 35 centimetres diameter. It was given by Soleil to the Academy of Sciences, and deposited at the "Conservatoire des Arts et Métiers." It is composed of 21 pieces, glued together, and fixed upon a flat pane which serves as a support.

Emboldened by this first success, Fresnel proposed to the Lighthouse Committee, at their sitting of 31st December 1820, to order the construction of a lenticular revolving light apparatus for the Cordouan lighthouse. The principal part of this apparatus was to include eight square lenses of 76 centimetres, forming together an octagonal prism inscribed within a cylinder of 2m. diameter. This proposal was adopted, and Mr. Soleil undertook the construction of these eight polygonal echeloned lenses. It was composed of 100 pieces of glass, glued together, and the flat pane, which in the trial lens serves as a support, has been done away with.

One of these new lenses was first tried in public on 13th April 1821. It was placed on the top of the Observatory buildings, together with two large reflectors, one by Lenoir, the other by Bordier-Marcot. The Lighthouse Committee, of which Mr. Becquey, director-general of the "Ponts et Chaussées," was chairman, went to the summit of Montmartre to judge of the effect. The result confirmed the inventor's previsions, and every one allowed the superiority of the lens over the reflectors. Meanwhile, Fresnel had already thought of improving these first essays. He had invented a machine for constructing circular rings, and M. Soleil was instructed to make eight large lenses constructed on annular principles. He soon finished some of them, and in September 1821 the Lighthouse Committee determined to try their effect at long distances. Fresnel had fitted up on the top of the "Arc " de l'Etoile" a revolving apparatus upon which were fixed two of these annular lenses, four polygonal lenses previously constructed, and four semi-polygonal lenses. At the focus, a four-wicked lamp was burning. The committee then went to Chateney, a village situated N.N.E. of Paris, 24½ kilometres distance from the "Arc de l'Etoile." The experiment took place during the night of 7/8 September 1821, and the results were adjudged as very satisfactory. The eight annular lenses that had just been constructed form part of the first flashing light apparatus of the 1st class that Fresnel himself fixed on the watch-tower of Cordouan, and which has lighted the entrance to the Gironde for more than 30 years.

If an idea is to be formed of the progress made in the science of lenticular lighthouses from its origin to later times, the three lenses before mentioned should be compared with the lenses of modern construction.

Fixed Light Apparatus.

First fixed light apparatus of $0{\cdot}50^{m}$ diameter. Invented by A. Fresnel, and constructed in 1824.

Fresnel, after his appointment to the Lighthouse Committee of 1819, first gave his attention to flashing lights; meanwhile, he had thought about obtaining fixed lights, and in the first design of the lenticular lighthouse that he submitted to the committee on 31st October 1820, he indicated, as a solution, the use of cylindrical lenses; but the Lighthouse Committee had thrown aside the fixed light system as possessing less reverberating power than revolving lights, and as being liable to be mistaken for the incidental lights of the coasts. The committee altered this decision later, and Fresnel then invented the system of fixed light apparatus ($0{\cdot}50^{m}$ diameter); in this apparatus the lenticular drum, which should be cylindrical, so as to give an uniform subdivision of light, shows a polygonal form of 16 fasces, because no lathe was then known for making cylindrical

pieces. The upper part is made up of two lenticular zones in the shape of a 16-panel cupola, every element of which is coupled with a plane mirror. The lenses unite in parallel fasces the rays emitted by the light, and the mirrors reflect them in the direction of the horizon.

A similar system, but having one lenticular zone only, is fitted at the lower part. The lamp has two wicks, and stands upon a plate raised or lowered by a jack between three leaders. With the polygonal form that had to be adopted, there were 16 directly receiving more light than the intermediate parts, but Fresnel, while constructing the instrument, discovered the means of greatly lessening this inequality, by alternating the shining directions of the lenticular cylinders with those of the two other parts. This first trial of a fixed light apparatus was demonstrated by Fresnel before the Academy of Sciences of Paris, at their sittings of 3rd May 1824. It was then inaugurated on the 1st February 1825 in the port of Dunkirk.

Catadioptric Rings.

First apparatus containing catadioptric rings, as well for fixed as for flashing lights. Invented by A. Fresnel, for lighting the St. Martin Canal, and constructed in 1825.

Annular lens, composed of dioptric and catadioptric elements, similar to those of apparatus No. 5, and constructed at the same date.

Models in wood of a similar apparatus, but on a larger scale. Study of A. Fresnel in 1825.

The last invention of A. Fresnel, that of the catadioptric rings, resulted from a request for information addressed to him by the Prefect of the Seine in 1825. It was a question of applying to lighting the quays of the St. Martin's Canal more powerful lamps than those used commonly in the city of Paris. This problem, to which Fresnel's attention was called, was the same as that of the port-lights apparatus, of which he had postponed the study because the sidereal reflectors of Bordier-Marcet were sufficient to supply the wants of the service.

The principal part of these small apparatus, that is, the lenticular cylinder, offered no theoretical difficulty. It was to proceed out of an echeloned section turning around the vertical axis; the only thing was to construct it in circular shape, because the polygonal shape would have been impossible for rings of 20 to 25 centimetres diameter. The question was not so easily solved as regards the accessory parts intended to utilise the luminous rays passing outside the cylinder, because the reflectors used in the other classes had to be reduced to very small dimensions. It was then that Fresnel thought of the phenomenon known in optics under the name of "total reflection," and imagined to substitute for the common reflectors, glass rings, within

which the luminous rays should be reflected without appreciable loss.

Fresnel's first conception for these circular rings was to direct the fasces through which the luminous rays pass perpendicularly to these rays, so as not to alter their direction; the reflecting surface would then have preserved the shape of the mirrors to be replaced, but hence resulted inconvenience, and a too great weight of glass. Fresnel found out that an inclined direction upon the rays could be given to these in and out going fasces, and these inclinations be combined, as well as the shape of the reflecting surface, so as to force the rays to emerge horizontally. The transverse section of the rings then became triangular instead of showing four sides, and the dimensions lessened.

In the apparatus to which Fresnel first applied this invention the diameter is reduced to $0{\cdot}20^{m}$; the cylinder is generated by an echeloned section composed of three elements and fills up a half circumference. The rays passing above this cylinder are gathered by four total-reflection rings, and this is effected by turning around the vertical point of the focus, the section of the catadioptric triangles just spoken off. Thus is obtained a fixed light apparatus, lighting up half the horizon. The lamps of the St. Martin's Canal having to be erected at 70 metres distance, it became necessary to give them a greater lateral than frontal intenseness. Fresnel succeeded in this by placing on each side a half annular dioptric lens, generated by the rotation of the section of the cylinder around an horizontal axis, parallel with the longitudinal direction of the quay, but he had moreover the happy idea of making the section of catadioptric triangles to revolve around this axis so as to form an annular lens, collecting around the focus an angle of great amplitude, and comprising at the same time dioptric and catadioptric rings.

The manufacture of these different circular rings offered serious difficulty, and Fresnel was obliged to set up a factory.

A first apparatus was completed in 1826, and submitted to the Lighthouse Committee towards the end of December. Four of these new lamps were finished at the beginning of 1827, but they could not be tried until after the inventor's death.

This study shows how Fresnel came to invent not only the section of catadioptric rings, and the use of these rings in fixed light apparatus, but also their application to annular lenses for flashing lights or for fixed lights. By uniting the pieces of dioptric elements and of catadioptric rings manufactured in Fresnel's time for the apparatus of the St. Martin's Canal, the annular lens was formed, and it may be considered as the type of all the annular lenses used in the lighthouses of different orders.

The model in wood represents an apparatus similar to the preceding, but having a diameter of $0{\cdot}25^{m}$ instead of $0{\cdot}20^{m}$. It is a study of Fresnel's which he did not carry out.

Lighthouse Lamp Burners.

One of the first burners, with four concentric wicks, was constructed in 1819–20 after experiments made by Arago and Fresnel.

A burner, with two wicks and outer wrapper for directing the draught, was constructed by Henry Lepaute in 1845.

A burner, with five wicks, of graduated shape, for mineral oil, with the last improvements adopted in the lighthouses of France, 1876.

When Fresnel undertook the improvement of lighthouses, he had to solve not only the problem of construction of the lenses, but also that of lamps with several wicks. The chemist Guyton-Morvau had already studied the question. In a paper read by him at the Institute in 1797, he stated that he had constructed 10 years before a lamp on the argand principle, with three concentric circular wicks, each having an inner and an outer draught. He acquired great intenseness, but the solderings of the burner were destroyed by the heat. About 1800 the watchmaker Carcel invented the lamp that bears his name, and in which the oil at the bottom is forced up by a pump towards the burner above which it overflows. This invention was to lead towards solving the problem of lamps with many wicks. Consequently, when Arago and Fresnel began, in 1819, their experiments with lamps, they forced up the burner oil in superabundance so as to refresh it, and thus avoid the inconvenience met with by Guyton-Morvau. The first trial took place in September 1819, with two-wicked and three-wicked burners, constructed after Fresnel's designs. After several hesitations, respecting chiefly the width to be adopted for the draught between the wicks, they succeeded in constructing a four-wicked burner that gave good results. It was tried 12th May 1820, in presence of the Lighthouse Committee.

The two-wicked burner was constructed by Henry Lepaute in 1845 for the lighthouse of Schevening in Holland. It has an outer cylinder for dividing the draught generated between the blast and the burner, and throwing back a part of it upon the light. It is the first application of this cylinder which exists in all modern burners.

The five-wick burner is now constructed for all the French lighthouses and for burning mineral oils. It contains an appendage through which the oil must pass before reaching the upper part of the burner. This apparatus, of which the arrangements were invented by M. Dénéchaux, acting engineer in ordinary at the lighthouse depôt, is intended to secure a continuous level, and comprises three tubes, juxtaposed, and open on the upper part at the proper height; the central tube

springs from the small reservoir which forms the basis of the burner, and in which the oil is forced by the machinery of the lamp; this oil, having no other exit, rises in the tube, and, arriving at the top, flows into the second tube, which carries it into the annular spaces containing the wicks; these it fills while keeping the same level as in the lateral appendage. As the quantity of oil forced up by the lamp is greater than the consumption, the excess comes down into the large reservoir of the lamp by flowing into the third tube over a fall rather higher than that cleared by the oil in reaching the burner. A horizontal disc of 30 millimetres diameter rises, at the height of 21 millimetres, above the central draught tube, and an outer cylinder divides in two the draught created between the burner and the glass. It is upon this outer cylinder that the glass-holder stands. In this burner the empty spaces between the wicks, intended for air passages, are $5\frac{1}{2}$ millimetres wide, while the spaces that contain the wicks are only $4\frac{1}{2}$ millimetres. In the burners constructed up to the present time, both widths are of 5 millimetres; this new arrangement seems to give better results. The burner has besides, on its upper part, a graduated shape, so that each wick is placed about two millimetres below the one which precedes it towards the centre. This arrangement, as yet adopted only for the Pilier lighthouse, has been found necessary since the burners, in each order of lighthouses, have had one burner added to them, and therefore wider. Its object is to lower the edge of the burner, in reference to the centre of the light, so as to reduce as much as possible the portion of light obscured by this edge in the lower part of the lenses.

Modern Lighthouse Apparatus.

Great annular lens, of the first order, $1{\cdot}10^{m}$ in diameter, Messrs. Barbier and Fenestre, constructors, 1867. This lens was constructed by Messrs. Barbier and Fenestre as a specimen of high class workmanship. Each ring is one single piece, the joints which divides the rings are inclined according to the direction of the ray refracted. The lens mounted on a pedestal revolves around a horizontal axis.

Lenticular panel, dioptric and catadioptric, for flashing lights of the second class, planned by the head engineer, Allard, and constructed by Mr. Henry Lepaute, 1876.

It forms part of an apparatus intended for the Pilier lighthouse, situated at the mouth of the Loire, and of which the tower has just been rebuilt. The character given to it in 1829 has been preserved; it is a fixed light varied by flashes every four minutes. To produce this character a fixed light apparatus has been adopted, of which two sectors of $\frac{1}{8}$th horizon, opposed to one another, are replaced by perfect annular lenses; it revolves at the rate of one turn in eight minutes. In order that the two kinds of lenses may be adjusted upon the edges, and have a common pinion-jack, the

focal distance, which is $0{\cdot}700^{m}$ for the fixed lenses, has been reduced to $0{\cdot}647^{m}$ for the annular lenses. The focal lamp has five concentric wicks, instead of four, as usual in lamps of the second class, because the light, being coloured red in certain directions, it was thought necessary to increase its intenseness.

The panel shows several novel arrangements, some of which are now for the first time applied.

1st. In the central or dioptric parts of the section, the joints that divide the elements, and therefore the lower sides of these elements, instead of being horizontal, are inclined according to the direction of the ray refracted. This system has several advantages: it does away with a triangular part of glass which is useless, and thus lessens the weight of the apparatus; it reduces in a large proportion the loss of light caused by horizontal joints; it makes less harsh and consequently less fragile, the outer angles of the elements, and besides diminishes their projection, thus enabling the dioptric lens to acquire a greater height.

2nd. The central lens (or dioptric) comprehends a vertical angle of 76 degrees, whereas, in the old sections, this angle was of about 60 degrees only, its elevation is thus increased from $0{\cdot}85^{m}$ to $1{\cdot}10^{m}$. This advantage is thus obtained, that the luminous rays meet the last dioptric element at the same angle as the first catadioptric ring, and suffer no more loss of reflection upon the one than upon the other.

3rd. The section commonly used in apparatus of the second class had been calculated for a three-wick lamp burner of $0{\cdot}074^{m}$ diameter. With a five-wick burner of $1{\cdot}110^{m}$ diameter, the inferior elements of the dioptric lens and the lower catadioptric rings, constructed after this old section, emit rays that are no longer in the proper direction, because the portion of light which the base of the burner leaves visible becomes perceptibly nearer to the lens than in the case of a three-wick burner. To lessen this defect, a graduated shape was given to the burner, by placing each wick $0{\cdot}002^{m}$ below the one preceding it on the side of the centre. This arrangement reduces neither the regularity nor the intensity of the light, and the part of the light, visible from each of the lower lenticular elements, becomes somewhat increased. Moreover, these lower elements have been calculated by determining for each of them a particular focus taken on the brightest line of the apparent part of the light, instead of on the axis itself of the lamp.

4th. The central lens and the lower rings are included in the same frame, the upper rings are set in a second frame, separated from the first by a metal cross-beam. In the annular lenses, this cross beam takes the shape of the arc of a circle having, like the rings, its centre on the optical axis; the result is that the rings remain intact, instead of having to be cut.

5th. The lamp, used at the focus of the lens, shows special arrangements due to M. Dénéchaux.

The lamp with five wicks for burning mineral oil has an intenseness of 36 Carcel burners, the fixed light apparatus produces an intenseness of 640 burners, and the annular lenses produce an effulgence of more than 5,000 burners.

Apparatus for electric revolving light, constructed by Messrs. Sautter, Limonier & Co., 1876.

This instrument is intended to produce, by electric light, a light revolving at intervals of 30 seconds. It includes a fixed light apparatus $0{\cdot}50^{m}$ diameter, lighting the three-fourths of the horizon, around which revolves, in eight minutes, a drum $0{\cdot}62^{m}$ diameter, and composed of 16 vertical lenticular elements.

In the section of the fixed light apparatus the central dioptric part fills vertically an angle of 76 degrees, which is greater than in the old sections. This arrangement is adopted in order that the luminous ray may meet the last dioptric element at the same angle as the first catadioptric ring, and should suffer no more loss by reflection upon the one than upon the other. The apparatus designed for an elevated position, the section of the several parts, except that of the two lowest catadioptric rings, has been calculated so as to throw the focal line of the emergent rays, 30 minutes below the horizontal line; in the calculation of the two lowest rings, this angle is increased by three degrees for the last but one, and by five degrees for the last, so that the light-house may remain visible at a short distance, that is by a navigator placed below the divergent cone emitted by the rest of the apparatus.

The 16 vertical lenses are contiguous, and are each composed of a single element, about 0·12 wide, the curve of which has been calculated so as to give with the electric light an horizontal divergence of three degrees seven minutes The duration of a flash is, accordingly, of about five seconds, and the interval between the end of a flash and the beginning of the following one is 25 seconds.

The maximum intenseness of the flash rises to about 60,000 burners, assuming at the focus an electric light of 200-burner power.

The light is produced in this apparatus, as in the light-houses established on the coasts of France, by means of a Serrin regulator and an electrical machine of the Compagnie l'Alliance.

Experiments have been made with the Serrin regulator at the lighthouse depôt since the year 1860. A model on a large scale has been constructed especially for the lighthouse service, and has always given good results.

The electro-magnetic machine has been, and is well known, designed by MM. Nollet and Joseph Van Walderen, in accordance with the same principle as the scientific apparatus of Pixii and Clarke. It produces alternate currents, and, as

it was in the first instance destined for the decomposition of water or for electro-metallurgy, it was provided with a commutator for bringing the currents into one constant direction. When the question was raised of applying it to the production of light, M. Van Malderen, who had then become the mechanical engineer to the Compagnie l'Alliance, conceived the idea of suppressing the commutator, which is difficult to maintain, and has the effect of more or less weakening the current. The luminous intensity was found to be appreciably augmented, and the fact was soon acknowledged that alternate currents are, *cæteris paribus*, more favourable regulators than those in a constant direction. The machines of the Compagnie l'Alliance had originally six discs; these were reduced to four when the improvements into the coils and the magnets permitted of a greater intensity being obtained with these smaller machines than with the former. In the case of lighthouses, where there cannot be too great intensity, the number of six discs has been preserved.

The central depôt in Paris has retained, since 1860, the first specimen constructed by M. Van Malderen of this machine, with the currents not brought into one constant direction. It has six discs, and carries 56 magnets; it is 1·63 meter high, and 1·43 metre in diameter; it gives less light than the present machines, but it works very well still, and serves for the experiments that are made at the depôt.

The first machine of the Compagnie l'Alliance may be regarded as the starting point of all the attempts which have since been made of economically transforming power into electricity, and consequently into light.

The researches by Fresnel, described in this notice of light-house apparatus, may be said to be the foundation of all present systems for this branch of scientific construction.

A. J. Fresnel was born at Broglie in France in 1788, and died in 1827 near Paris. His discoveries and researches were especially in the diffraction and polarization of light.

*** The objects referred to in the foregoing account of Fresnel's researches are preserved in Paris by the lighthouse service of France.

It should be recorded that lighthouse illumination by electricity has been firmly established in Great Britain. Three powerful installations of the system may be noted. That at the South Foreland lighthouse on the coast of Kent, first shown in 1858–9 under Professor Holmes' arrangements and machinery; that on the Isle of May, off the east coast of Scotland, exhibited 1866; and that at St. Katherine's Point, Isle of Wight, opened 1 May 1888. Gas light is also approved for lighthouse illumination, installations of it having been lately carried out on the coast of Ireland, at Galley Head, at Howth, and near Belfast, on Mew and Tory Islands; the lighthouses being gas lighted under Mr. J. R. Wigham.

Appendix.—Group IX.

Miscellaneous Objects.

A Figure-head. Carved figure-head in wood, native work, 1860. For a war canoe of New Zealand native tribes.
Lent by H.R.H. the Duke of Edinburgh, K.G. 1872.

Transferred from Art Museum. 1881.

Wooden Figure Head of a native canoe, New Zealand. Carved in hard wood and painted red.
Presented by Mr. R. H. Rhodes. 1876.

Figure Head for a ship. Full size, Coloured.
Mr. R. Hall. 1865.

Ornamental Carved Work, in wood, for bow and stern of ships, proposed for H.M.'s ships of the "Royal Oak" class; by Mr. Hellyer, carver to the Admiralty. 1860. 1864.

Cap worn by sailors on board the "Infernal," bomb ketch. Commanded by the Hon. Capt. Perceval (Lord Egmont), at the siege of Algiers, in 1816.
Presented by Sir W. Trevelyan, Bart. 1869.

Two smooth-boring Auger Bits. Recommended by the late Mr. Joseph Tucker, Joint Surveyor of H.M.'s Navy from 1813 to 1831, for the reduction of decay in wooden ships.
Presented by Mr. J. S. Tucker. 1865.

Model. Machine for rolling bars of metal for bolts, &c.
Designed by Sir Robert Seppings, 1829. 1864.

Model illustrating Mr. H. S. Harland's proposed apparatus for saving life on lakes and rivers, and showing the installation on the waterside. Nine-thread tarred cordage to be employed.
Presented by Mr. H. S. Harland, Brompton, Scarborough. 1874.

Life Saving Buoy. Rodway's. Japanned tin cylinder 16 ins. long, 4½ ins. diameter, weight 23 ozs.
Lent by Major H. B. Rodway, Torquay. 1879.

MAT for stopping holes in iron ships. Invented by Lieut. Makaroff, Imperial Russian Navy.

Messrs. Creswell & Co. 1877.

Note.—These mat are used in the Russian Imperial Navy for stopping shot holes chiefly in iron-clad ships of war. A special drill for ship's company in using and securing these mats has been adopted. The mat is made of hempen fibre backed with canvas, and is saturated with tar.

DRAWING. Coloured drawing; a proposed method for preventing the sinking of ships at sea by means of outside suspended air-bags.

Presented by the Rev. R. G. Sayers. 1881.

Three MODELS and a LITHOGRAPH; illustrating the late Mr. E. Thompson's proposals and designs, 1875–1878, for the construction of unsinkable war ships, merchant ships, life-boats, and other vessels.

The late Mr. E. Thompson. 1878.

DIAGRAMS and REGULATIONS illustrating the "Rule of the Road" at sea, for sailing and steamships.

Mr. Thomas Gray, Board of Trade. 1872.

SECTIONAL MODEL of a diving bell for sub-marine explorations. The model illustrates an arrangement by Dr. John Taylor, for supplying air to the bell in an upward jet near the mouth, so that in case of the bursting of the air hose or the failure of the stop-valve (usually placed on the top of the bell) the water would only rise to the level of the air-pipe nozzle.

Presented by the late Dr. John Taylor, M.D., Glasgow. 1874.

A PANTAMETER. For indicating the specific gravity of iron, wood and coal, the sectional area, and the cubic contents of any body that will go into the machine.

Mr. A. M. Bennett. 1868.

Silver CLARET JUG and SALVER presented in 1858 by a company of gentlemen and engineers, to the late Sir Francis Pettit Smith (1808–1874), in recognition of his exertions in the application and development of the screw propeller for the propulsion of ships.

Bequeathed by the late Sir Francis Pettit Smith. 1871.

TWO MODELS. Working Models of coal-screening and ship-loading shoots. Mr. A. Rigg's plans.
Lent by Mr. A. Rigg, 42, Old Broad Street, E.C. 1870.

HALF BLOCK MODEL. Iron-built trading screw steamer; with well deck, and raised quarter.
Lent by Mrs. B. Woodcroft. 1876.

TWO BEARINGS for shafts fitted with white metal.
Messrs. J. Woods & Co. 1864.

DRESSING CASE for ships' cabin. Japanese, modern.
From the London International Exhibition, 1874.
Presented. 1875.

PORTION of the original Submarine Telegraph Cable, designed by the late Mr. Crampton (1816–1888), and laid between Dover and Calais in 1851.
Lent by the late Mr. T. R. Crampton. 1885.

Note.—The insulation of this piece of cable was tested in 1885, and found perfect.

NOTE ON ELECTRIC LIGHTING FOR SHIPS.

The great advance during the last few years in the application of electricity to the purposes of illumination seems to call for some notice, as it is now so frequently applied to the lighting of sailing ships and steamships.

The researches and experiments in electricity of Faraday 1791–1867, Wheatstone 1802–1875, and many other workers during the present century, led to the practical application to the service of man of the electric current and its gift of light.

The electric light appears to have been first applied to naval tactics in 1871, by its use in swift torpedo boats for search work during the night. Gradually the electric light has been extended and adapted for ships of war which are now generally fitted with special machinery for developing the light, and by it illuminating not only the vessel's search lights and signal lights, but also every part of her internal accommodation.

In vessels of the mercantile marine the electric light soon became an integral part of the equipment, and it may be said that at the present time no ocean-service merchant steamships of the first class, and in some cases sailing vessels, proceed to sea and their duties, without a special installation of steam power machinery for producing electric light, and by it illuminating the vessel's interior compartments and the passenger accommodation.

SUPPLEMENT.

CATALOGUE OF SHIP MODELS

AND

MARINE ENGINEERING

IN THE

SOUTH KENSINGTON MUSEUM.

LONDON: MARCH 1889.

SUPPLEMENT.

1889.

Catalogue of Ship Models and Marine Engineering in the South Kensington Museum.

CLASS I.

IMPERIAL MARINE.

WHOLE MODEL, RIGGED. H.M. Twin-screw despatch vessels "SURPRISE" and "ALACRITY." Built and engined, 1885, at Jarrow.

Lent by Palmer's Ship-building and Iron Company, Jarrow-on-Tyne. 1888.

Note.—These steel-built despatch steamers are of the following dimensions: length 250 ft.; breadth 32 ft.; depth 20 ft. Displacement 1,400 tons. Average speed at sea 18½ knots. The compound inverted engines have two cylinders, one 26 ins. and the other 50 ins. diameter. Stroke 34 ins. Horse-power 3,017 indicated.

CLASS I.

PADDLE-WHEEL STEAMERS.

WHOLE MODEL. Paddle-steamer "JEANIE DEANS." Built of iron, 1884, for the North British Steam Packet Company.

Lent by Messrs. Barclay, Curle, & Co., Whiteinch, Glasgow. 1888.

Note.—The Clyde passenger steamer "JEANIE DEANS" is 210 ft. long; 20 ft. wide, and 7 ft. 6 ins. deep.

Gross tonnage 270. She is driven by a single diagonal engine, indicating 1,050 horse-power. The cylinder is 50 ins. diameter. The stroke 72 ins. The vessel runs to and from Glasgow and Greenock. A "Haystack" upright circular boiler of steel supplies steam. The vessel was built and her machinery supplied by Barclay, Curle, & Co.

WHOLE MODEL. Passenger paddle-steamer "OZONE." Built 1886, at Glasgow, for the Bay Excursion Company, Melbourne. Length 260 ft.; breadth 28 ft; depth 11 ft. 5 ins. Tonnage 572 tons. The engines indicate 2,680 horse-power. Diameter of cylinders 47 ins. and 85 ins. Stroke 5 ft. 6 ins. Mean speed 21 miles per hour.

Lent by Messrs. Napier, Shanks, and Bell, Yoker, Glasgow. 1888.

Note.—The "OZONE" is fitted with inclined cylinder compound engines and steel boilers. Messrs. Rankine & Blackmore, Greenock, furnished her machinery; Messrs. Napier, Shanks, and Bell, built the vessel.

CLASS I.

SCREW PROPELLER STEAMSHIPS.

WHOLE MODEL, rigged: "Clan" Line screw steamship "CLAN MACARTHUR." Built of steel, 1883, by Scott & Co., Greenock.

Lent by Messrs. Cayzer, Irvine, & Co., 109, Hope Street, Glasgow. 1888.

Note.—The "CLAN MACARTHUR" is one of a line of steamers trading between Great Britain and India. Length 382 ft.; breadth 44 ft.; depth 28 ft. Tons, net register, 2,635. Her engines are inverted, direct-acting, and compound, having two cylinders 48 inches and 86 inches diameter. Stroke 60 ins. Horse-power, indicated, 2,376. Steam is supplied by two boilers having 12 furnaces fitted with Fox's corrugated fire tubes. The vessel is lighted throughout by electric light. The Clan Line comprises a fleet of about 24 steam vessels.

WHOLE MODEL. The Union Cape Mail screw steamship "MEXICAN." Built and engined 1882 at Sunderland. Length 392 ft.; breadth 47 ft.; depth 33 ft. 8 ins. Tonnage, gross, 4,669. Her engines are compound, inverted and surface-condensing, indicating 3,700 horse-power. Diameter of cylinders 50 and 94 ins.

Lent by The Union Steamship Company, 11, Leadenhall Street, E.C. 1888.

HALF MODEL. The Union Cape Mail screw steamship "TARTAR." Built and engined, 1883, at Glasgow. Length 376 ft.; breadth 47 ft.; depth 30 ft. Gross tons 4,359.

Lent by The Union Steamship Company, 11, Leadenhall Street, E.C. 1888.

Note.—In 1888 the S.S. "TARTAR" was refitted by T. Richardson & Sons, Hartlepool, with engines on the triple expansion compound system, indicating 4,750 horse-power. The "TARTAR" is built according to Admiralty requirements for Imperial service, and is lighted by electric lights. The S.S. S.S. "ATHENIAN," "SPARTAN," and "TROJAN," of the Union Company's Service, have also been refitted by T. Richardson & Sons with triple expansion compound engines.

WHOLE MODEL. The Cunard Line screw steamships "UMBRIA" and "ETRURIA." Built and engined, 1884, at Glasgow. Length 520 ft.; breadth, moulded, 57 ft.; depth 40 ft. Tonnage, gross, 8,000. Horse-power 13,500 indicated. Both vessels fulfil Admiralty requirements for Imperial service.

Lent by The Cunard Steamship Company, Liverpool. 1888.

Note.—Messrs. John Elder & Co., Shipbuilders and Engineers, Glasgow, built and completed the steamships "UMBRIA" and "ETRURIA." See page 56.

HALF BLOCK MODEL. Screw steamships "GLENGYLE" and "GLENSHIEL." Built 1886. Length 370 ft.; breadth 45 ft.; depth 26 feet 9 inches. Tons, net, 2,244; gross, 3,455.

Lent by the London and Glasgow Engineering and Shipbuilding Company, Glasgow. 1888.

Note.—The Glen Line consists of a fleet of steamers trading chiefly with India and China. They have been for the most part built and engined by the London and Glasgow Shipbuilding and Engineering Company, at Glasgow.

WHOLE MODEL. Twin-screw steamer "ISLANDER." Built of steel, 1888, for the Canadian Pacific Navigation Company, Victoria, B. C. Length 240 ft.; breadth 42 ft.; depth 14 ft. 8 ins. Tonnage 1,500. Horse-power 3,000 indicated. The engine cylinders are 20 ins., 31 ins., and 52 ins. diameter. Stroke 3 ft. Mean speed 16¼ knots per hour.

Lent by Messrs. Napier, Shanks, and Bell, Yoker, Glasgow. 1888.

Note.—With the model five photographs are lent, showing interior accommodation and fitting-up of the "ISLANDER."

It will be observed that the vessel is fitted saloon fashion, all the passenger berthing being above deck, and atop of all a large promenade space provided. Her engines, on the triple expansion compound system, were built and her machinery furnished by Messrs. Dinsmuir & Jackson, Govan. Four boilers of steel supply steam at 160 lbs. per square inch pressure. The vessel was built by Napier, Shanks, & Bell, Yoker, and is lighted throughout by electric light.

WHOLE MODEL. Screw steamship "HARE." Built 1887. Length 216 ft; breadth 29 ft. 8 ins.; depth 15 ft. 4 ins. Gross tonnage 771. The engines indicate horse-power. Diameter of cylinders 24 ins., 38 ins., and 58 ins. Stroke, 42 ins. Speed 13¾ knots per hour.

Lent by Messrs. Barclay, Curle, & Co., Whiteinch, Glasgow. 1888.

Note.—The "HARE," owned by Messrs. John Burns & Co., Glasgow, is one of a fleet of screw steamships running between Glasgow and Ireland. She is a cargo and passenger carrying ship. The vessel and her machinery were entirely completed by Barclay, Curle & Co.

WHOLE MODEL, full rigged. Screw steamship "CITY OF VIENNA." The "City" line of steamers, on service between this country and India.

Lent by Messrs. Geo. Smith & Sons, 45, West Nile Street, Glasgow. 1888.

Note.—The "CITY OF VIENNA" is now being built of steel by Messrs. Workman, Clark & Co., Belfast. Her length 412 ft.; breadth 46 ft. 6 ins.; depth 31 ft. 10 ins. Tonnage . Her triple expansion compound engines will be fitted by Messrs. J. & J. Thomson, Finnieston Works, Glasgow. They will be of sufficient power to drive the vessel at 14 knots per hour. The boilers will be fitted up with Howden's system of forced draught. The City Line comprises a fleet of 12 to 15 steamships.

WHOLE MODEL. Passenger screw steamships "LOCKSLEY HALL," "BRANKSOME HALL," and "RUFFORD HALL." Built of steel and engined at Jarrow 1887–1888. Length 380 ft.; breadth 45 ft.; depth 30¼ ft. Dead weight 6,000 tons. Total displacement on 24½ ft. draught 9,080 tons.

Lent by Palmer's Shipbuilding and Iron Company, Jarrow-on-Tyne. 1888.

Note.—Each of these vessels is driven by triple expansion compound engines indicating 2,100 horse-power. The diameter of cylinders 29 ins., 47 ins., and 76 ins. Stroke 51 ins. The boiler working pressure of steam 150 lbs. per

square inch. Average speed at sea, when loaded, 11 knots per hour. The vessels were built for Messrs. R. Alexander & Co., Liverpool. Palmer's Shipbuilding and Engineering Company also at this time contributed again for exhibition a whole model, rigged, H.M.S. "SURPRISE" and "ALACRITY," swift twin-screw despatch vessels, completed at Jarrow in 1885 for the British service.

CLASS I.

SAILING SHIPS.

HALF-BLOCK MODEL. The barque "MAIDEN CITY." Built of steel, 1887. Length 212 ft.; breadth 35 ft.; depth 21 ft. Tons, net, 1,200. Dead-weight capacity, 1,950 tons.

Lent by Mr. C. J. Bigger, Foyle Shipyard, Londonderry. 1888.

HALF-BLOCK MODEL. The barque "CUPICA." Built of iron, 1888. Tons, net, 1,040. Dead-weight capacity 1,650 tons. Dimensions 200 × 34 × 20 feet.

Lent by Mr. C. J. Bigger, Foyle Shipyard, Londonderry. 1888.

Note.—The sailing ships "MAIDEN CITY" and "CUPICA" were built and fitted out at Londonderry for private owners: the "CUPICA" for W. H. Ross & Co., Liverpool, the "MAIDEN CITY" for Thomson, Dickie & Co., Glasgow.

HALF-BLOCK MODEL. The four-masted sailing ship "FALLS OF EARN." Built of iron, 1884, for Messrs. Wright and Breakenridge. Tonnage 2,290. Length 300 ft.; breadth 42 ft.; depth 24·6 ft.

Lent by Messrs. Russell & Co., Port Glasgow, and Greenock. 1888.

Note.—The sailing ship "FALLS OF EARN" is fitted with steam appliances for the general heavy work of the vessel. The ship was built and fitted out by Messrs. Russell & Co.

WHOLE MODEL, rigged. Racing sailing yacht "VOLUNTEER."

Lent by Mr. Samuel Smiles, Glasgow. 1889.

Note.—The model represents the American yacht "VOLUNTEER," matched in 1887 against the British yacht "THISTLE." The American yacht was built by Pusey, Jones & Co., Wilmington, Delaware, U.S.A. The British yacht was built at Glasgow by D. & W. Henderson. Both yachts measured Y.M. tons 89. They greatly differed in design. The sailing matches took place at New York in

the autumn of 1887. Some account of the yachts "VOLUNTEER" and "THISTLE" was published in the *Scientific American Journal*, October 1887.

CLASS I.

RIVER CRAFT.

FULL SIZE GONDOLA. Used on the Canals of Venice. Length 34 ft; breadth 4 ft. 6 ins.

Lent by Mr. A. Morgan. 1888.

Note.—The gondolas used on the canals of Venice are employed for locomotion about the city by private owners and public service entrepreneurs. They are usually manipulated by two men, one forward and one aft; but a single "gondolier" (hand) also manœuvres these craft with great dexterity. Steam screw launches have lately been put on the canals for public service. They serve the vocation of the public stage omnibus ashore.

HALF-BLOCK MODEL. River Clyde Ferry steamers, "CLUTHA."

Messrs. T. B. Seath & Co., Broomielaw, Glasgow. 1889.

Note.—These screw propeller vessels work on the River Clyde as passenger ferry steamers. They are of two sizes: the larger plying up and down the river, the smaller ferrying across the river. The small "CLUTHAS" run either end first and are fitted with two screws. The larger are single or twin-screw vessels.

CLASS III.

SCREW-PROPELLER ENGINES.

WORKING MODEL, on a scale of 3 ins. to 1 ft. Triple expansion surface-condensing engines fitted to the screw steamer "FLAMBORO," 1886. Indicated horse-power 1,000. Cylinders 22 ins., 35 ins., and 58 ins. diameter. Stroke 42 ins. The propeller is 15 ft. 4 ins. diameter; 17 ft. pitch, and has 54·8 square feet surface.

Lent by Palmers' Ship-building and Iron Company, Jarrow-on-Tyne. 1889.

Note.—This model represents with complete detail a set of three-cylinder inverted compound engines driving three cranks on the engine-shaft—a type of engines approved for screw steamships and adopted for vessels of Imperial and mercantile marine services.

COLOURED DRAWING.—Moving diagram; scale, 1 in. to 1 ft. Sectional elevations of the compound quadruple expansion engines of the screw steamship "BUENOS AYRES," 1887. Tons, 5,200.

Lent by Messrs. Denny & Co., Engine Works, Dumbarton. 1888.

Note.—These quadruple expansion engines, constructed and designed under Mr. Walter Brock, indicate 4,300 horse-power. The cylinders are 32 ins., 46½ ins., 64½ ins. and 92 ins. in diameter. Stroke 5 ft. Boiler steam pressure 170 lbs. per square inch.

PHOTOGRAPH. The compound engines of the screw steamships "GLENGYLE" and "GLENSHIEL." Built 1886. Diameter of the three cylinders 34 ins., 53 ins., and 87 ins. Stroke 54 ins. Indicated horse-power 3,500.

Lent by the London and Glasgow Engineering and shipbuilding Company, Glasgow. 1888.

Note.—The steamships "GLENGYLE" and "GLENSHIEL" belong to a fleet of screw propeller vessels, trading eastward, a nd known as the "Glen" line of steamers. The fleet hails from Glasgow; some of its vessels are remarkable for high speed. The ships are for the most part built, engined, and completely fitted out by the London and Glasgow Shipbuilding and Engineering Company at Glasgow.

PHOTOGRAPHS. Triple expansion engines of the Cape mail screw steamship "ATHENIAN."

Messrs. T. Richardson & Sons, Hartlepool. 1889.

Note.—The "ATHENIAN," "SPARTAN," and "TROJAN" screw steamships of the Union Company Cape Mail service have each been refitted 1886–7 by Messrs. Richardson & Sons with three-cylinder inverted three-crank compound engines. The new arrangement, and the new boilers of steel, working at 160 and 170 lbs. steam pressure per square inch, have shown, it appears, a gain in power of 1,400 horses indicated, a gain in speed of 1½ knots per hour, and a considerable measure of economy in fuel.

DIAGRAM, showing the principles on which Rigg's Three-cylinder Revolving Engine is arranged.

Mr. A. Rigg, 42, Old Broad Street, E.C.

1889.

Note.—The drawing relates to a new form of high-speed engine for driving screw-propeller steam launches or for other work, designed and brought out by Mr. Rigg, 1887–1888. The engine is essentially a three-cylinder high-speed direct acting engine, and has been tried in the steam launch "DEVA" on the Thames, 1888.

MODEL AND DRAWINGS. Morton's slide valve driving gear.

Lent by the Proprietors of Morton's Valve Gear Patents; 157, West George Street, Glasgow.

1889.

Note.—The method employed to derive driving motion for steam-engine slide valves from some moving part of the engine itself, and thereby modifying or obliterating the use of eccentrics and their attachments for the purpose, has been the study of several engineers: Hackworth, 1849; Engelmann, 1859; Joy, 1879; Marshall, 1880; Bremme, 1884; and others. Morton's gear was fitted in 1885 to a small locomotive engine constructed by Dick, Kerr & Co., Kilmarnock. It has also been applied to marine engines.

CLASS I.

IMPERIAL MARINE.

WHOLE MODEL. Masted and with spars. H.M.S. "VANGUARD," 80 guns. Built at Pembroke Dockyard, 1835. Designed by Sir Wm. Symonds. Length, 190 ft.; breadth, 57 ft.; depth, 23 ft. 4 ins. Tonnage, 2,609.

Lent by Mr. J. W. Eagles, Hamilton Gardens, N.W.

1889.

Note.—The model is built and copper fastened. The scale is $\frac{1}{4}$ in. to 1 ft. The ship is on launching ways and cradled. There was also built on the same lines the "GOLIATH," in 1842, at Chatham. The armament of the "VANGUARD" was as follows:—

Lower deck	20	-	32-pounder guns.
	8	-	8-inch guns.
Main deck	24	-	32-pounder guns.
	4	-	8-inch guns.
Quarter deck	24	-	32-pounder guns.
Total	80		

WHOLE MODEL. Masted and rigged. On about $\frac{1}{2}$ inch scale. It represents a 50-gun Sailing Frigate of H.M.'s Navy; said to have been commanded by Captain Marryat. The model is fitted out, and shows guns, the flush upper deck arrangement, main deck with its complete battery, and other details. The model is said to have been built under Captain Marryat's supervision.

Presented by Mr. D. H. Macfarlane. 1883.

Note.—The model, in 1889, was re-set up by Museum attendant, H. Cole.

The collection of Indian Native Vessels and Boats (pages 105 *to* 111) *was exhibited in full from* 1880 *to* 1885. *In consequence of the space occupied being required for other purposes, the collection was withdrawn in* 1886, *and it is now represented by a few illustrations only.*

Similarly for want of sufficient space to display it in full, the collection of Models of Chinese Native Fishing and other Vessels, presented in 1883 *to the Museum (pages* 113 *to* 124) *is at present illustrated in the ship model collection by a few examples only.*

The collection of Native Fishing and other Vessels of the Straits Settlements (pages 111, 112) *will be found fairly well represented.*

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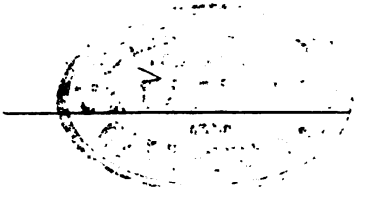

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